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STE/ICE-R DESIGN GUIDE
FOR
VEHICLE DIAGNOSTIC CONNECTOR ASSEMBLIES

Contract DAAE07-88-C-R029
Work Directive GE-3/3

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FOREWORD

This STE/ICE-R Design Guide for Vehicle Diagnostic Connector Assembly (DCA) has been prepared in compliance with Work Directive GE-3/3 of Contract DAAE07-88-C-R029.

The primary purpose of this Design Guide is to aid manufacturers of Army vehicles/equipment in developing Diagnostic Connector Assemblies that will allow the mechanic to test the vehicle/equipment without disassembly. The content of this guide has evolved from on-vehicle experience and extensive consultation with vehicle manufacturers during both the vehicle DCA design phase and the STE/ICE-R Vehicle integration phase. Review and study of this document will provide direction for most of the questions and problems that first time designers commonly experience.

For additional information and assistance to resolve questions not addressed in this guide and the referenced documents, contact the TACOM Diagnostic Branch (AMSTA-RVD) and/or TMDE/ATE office (AMSTA-MD).

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INTRODUCTION

The purpose of a Diagnostic Connector Assembly (DCA) is to permit (without disassembly) the mechanic to easily perform a readiness check on the vehicle/equipment engine and accessories.

The purposes of this Design Guide are to acquaint vehicle manufacturers with the STE/ICE-R system and to explain how to implement the Diagnostic Connector Assembly (DCA) into their vehicles.

To design your DCA, you must generate a test allocation matrix as described in Chapters 1 and 2. From this matrix determine your DCA class (a skeleton schematic for that DCA class is provided in Appendix A-3). Use Chapter 5 to customize the skeleton DCA schematic to fit your vehicle/equipment needs. To implement the design (installation, standard components, etc.), use the information shown in Chapters 3 and 4. Chapters 6 and 7 are provided to assist you in verifying and testing the design.

Additional information on the STE/ICE-R set and its use can be found in the STE/ICE-R Operator's and Organizational Maintenance Manual TM-9-4910-571-12&P. If questions still persist, further information can be obtained from the TACOM Diagnostic Branch (AMSTA-RVD) and/or TMDE/ATE office (AMSTA-MD).

CHAPTER 1
THE STE/ICE-R SYSTEM

1.1 Background

The modern U.S. military services are faced with a vehicle fleet maintenance problem of growing proportions. The increasing complexity of military vehicles, restricted accessibility of components and limited availability of skilled mechanics have compounded the problem of malfunction diagnosis. The seriousness of the problem is magnified by the fact that maintenance concepts must better support and be compatible with land combat operations. Vehicle readiness on the battlefield is a prime objective. Vehicles must be serviced rapidly especially at the edge of battle. Assessment of vehicle conditions and maintenance is critical to sustain combat operations.

The goal of high levels of vehicle readiness at economical costs was impossible to achieve with former method of malfunction diagnosis. Incorrect diagnosis of vehicle faults often resulted in replacement, evacuation, or "repair" of serviceable parts. The mechanics's need for help in diagnosing vehicle component problems has been thoroughly documented by the Army. A study(1) found that thirty to sixty-five percent of engine/engine accessory components replaced were, in fact, serviceable. Twenty-one percent of the replaced engines were found to be fully operational.

The major causes of incorrect engine and vehicle fault diagnosis are:

- Obsolete test equipment.
- Mechanic training limitations.
- Technical Manuals are difficult to use.
- Maintainability/Testability not emphasized in vehicle developments.

The fact that faulty malfunction diagnosis continued to be a major problem in vehicle maintenance is illustrated by an Army survey that found thirty percent of a sample group of one hundred eighteen track vehicle mechanics incorrectly diagnosed mechanical malfunctions. In a test conducted at Fort Carson, thirty-five percent of the generators, regulators, alternators, distributors and starters returned as unusable were actually serviceable.

Similar evaluations were recorded during visits to other armor units in CONUS and in USAREUR. This situation reflects unsuitable test equipment, inadequate technical documentation, and shortcomings in training.

Recognition of the many vehicle maintenance problems and the limitations of all test equipment led the Army to issue a Small Development Requirement (SDR) in 1973

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(1)"Faulty Diagnosis of Repairable Components", a report to the board inquiry on the Army Logistics Systems, Lieutenant General Frederick J. Brown, Chairman, 1966.

for test equipment to assist the organizational level mechanic in fault detection on internal combustion engine powered material. The SDR directed that the test equipment must be:

- Simple to use and understand.
- Easily connected to vehicle.
- Capable of testing gasoline and diesel vehicles.
- Operable in Army tactical/automotive environment.
- Low cost for deployment at Organizational Level (motor pool).
- Adaptable to expanded test requirements.
- Accompanied by simplified troubleshooting instructions.

The test equipment had to permit the mechanic to detect the troubles in engines including engine electrical and fuel systems in as little as twenty minutes. The goals of this development were to increase vehicle readiness, reduce maintenance labor costs, and eliminate the needless replacement of components.

1.2 STE/ICE-R - General Information

The original STE/ICE system was type classified "standard" by the U.S. Army on September 27, 1978, after completion of Development Tests and Operational Tests.

Simplified Test Equipment for Internal Combustion Engines - Reprogrammable (STE/ICE-R) is the result of new developments in vehicle test technology. The test capability is based on vehicle failure histories, cost analysis, and extensive consultation with personnel at all levels of maintenance. STE/ICE-R satisfies the vehicle fleet support requirement for power plants and related accessories of tactical and combat vehicles at the Organizational Maintenance level and can support many requirements at the Direct Support level.

STE/ICE-R is microprocessor-based and field-portable. It provides significantly increased capability over former Army test and diagnostic equipment. It was designed for ease of use, low cost, and high reliability. It is militarized for operation in maintenance shops and in the field. In addition to measurements such as speed, pressure, vacuum, temperature, voltage, current, resistance, starter peak current, and dwell, the system electronically determines compression unbalance in engine cylinders, and performs power tests, without external dynamometers on gasoline and diesel engines.

The STE/ICE-R system includes three major items of equipment:

- Vehicle Test Meter (VTM)
- Transducer Kit (TK)
- Generic Diagnostic Connector Assembly (DCA).

The VTM and TK comprise the STE/ICE-R Set which is carried to the vehicle in a transit case (see Figure 1-1). The DCA is built into vehicles to be tested. It includes transducers, electrical connections and a vehicle harness which brings all test points to a conveniently-mounted diagnostic connector (Figure 1-2).

The VTM interfaces to the vehicle through the DCA or with the Transducer Kit (TK). Although the DCA is the mechanics optimized mode of operation, practical limitations preclude wiring of all possible measurements. The vehicle manufacturer should be

Figure 1-1. STE/ICE-R Set

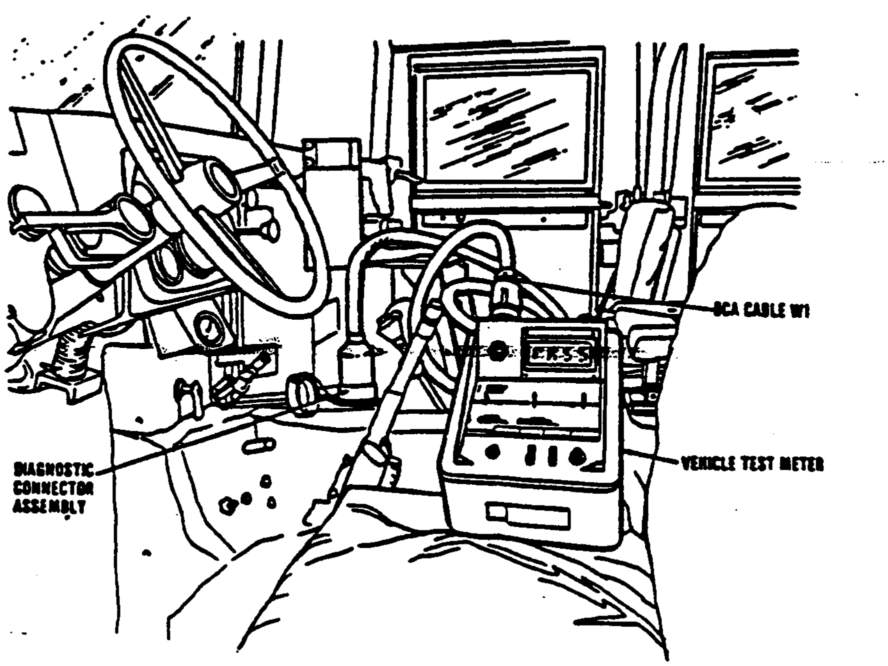

Figure 1-2. Diagnostic Connector Assembly Application

aware that the Transducer Kit can supplement DCA measurements to find the cause of the problems detected during readiness check. It also provides test capability for other vehicle systems and vehicles not equipped with DCAs.

The Transducer Kit contains two pressure transducers (vacuum to 25 psi, and 25 to 1,000 psi), a clamp-on current probe (0 - 1500 amps), a tachometer for diesel engine speed measurement, and electrical test probes. Various cables, adapters and fittings are also included to allow the test system to connect to the vehicle under test and to assure that the system is adaptable to the military fleet of vehicles.

The design of the STE/ICE-R VTM was influenced by two philosophies. The first was to minimize complexity at the operator interface and the second was to make maximum use of a microprocessor to decrease the need for special purpose hardware.

The STE/ICE-R VTM has forty eight thousand bytes of electrically erasable programmable read-only-memory to allows its internal information to be changed as new vehicles are added. Figure 1-3 shows the STE/ICE-R general purpose hardware architecture.

The VTM (Figure 1-4) measures vehicle parameters and displays the results as either Pass/Fail or a digital value in units familiar to the mechanic (psi, RPM, Volts, etc.). Readings are properly scaled, the mechanic does not decide where the decimal point belongs or what range of measurement is read.

Simplicity of operation is illustrated by standard tests where the mechanic simply inputs a test number and the measurement result appears on the digital display. For each test of this type, the microprocessor executes the following tasks:

- Reads TEST SELECT switches.
- Validates test selection and operation conditions. Displays error message if required.
- Selects test multiplexer channel.
- Controls channel characteristics, offsets, gain, bandwidth, etc.
- Controls special purpose signal processing circuitry.
- Reads analog to digital converter.
- Scales and outputs results to display.

Furthermore, the microprocessor makes possible the system's special test for:

- Cylinder Compression Unbalance.
- Engine Power.
- Battery Resistance and Starter Current First Peak.
- Confidence Test.

STE/ICE-R has self-teaching features and built-in reference aids which make it easy to use. Prompting messages remind the mechanic to "crank the engine", or perform other test actions. Error Messages alert the operator to improper test numbers,

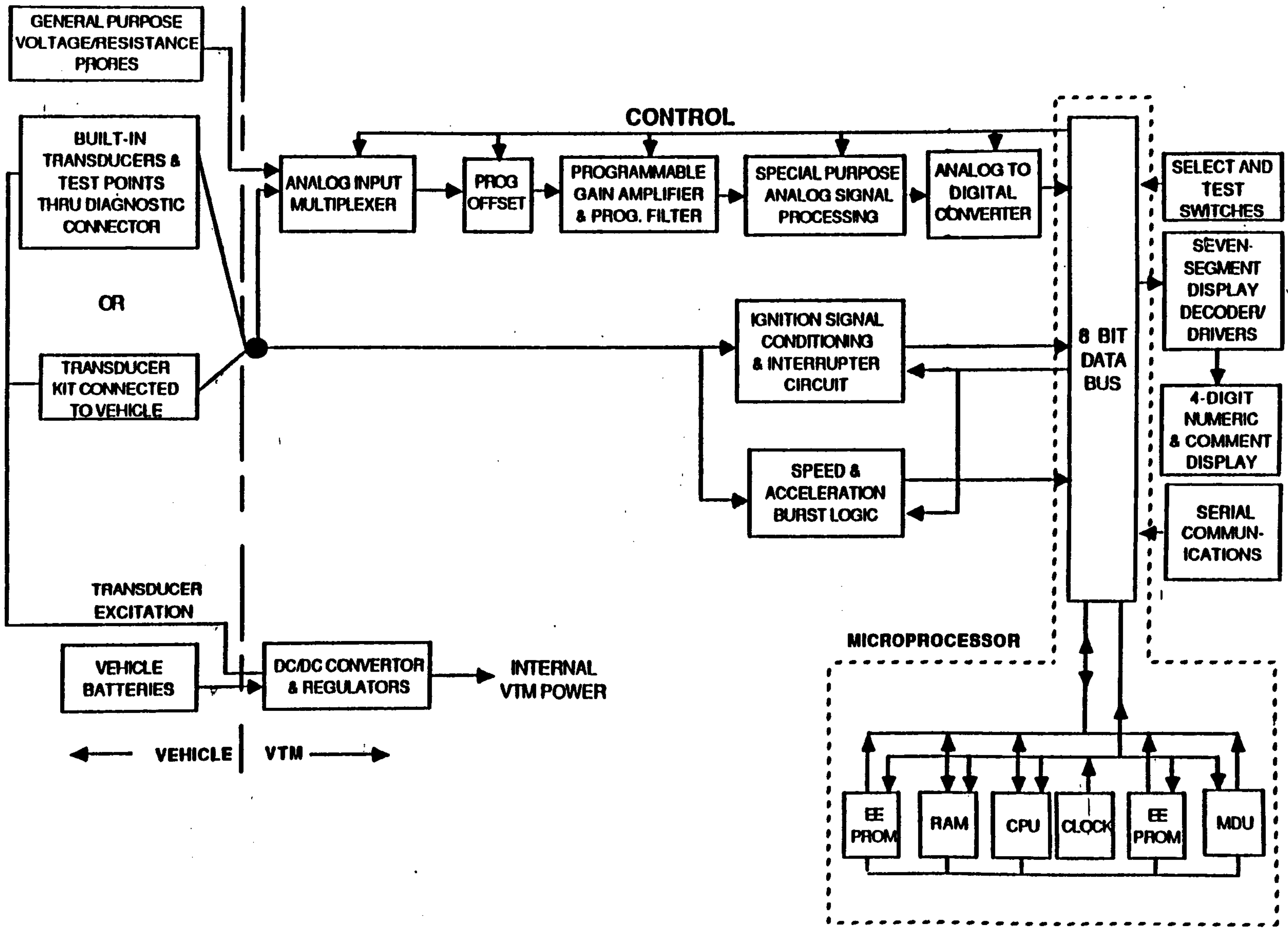

Figure 1-3. STE/ICE-R System Architecture

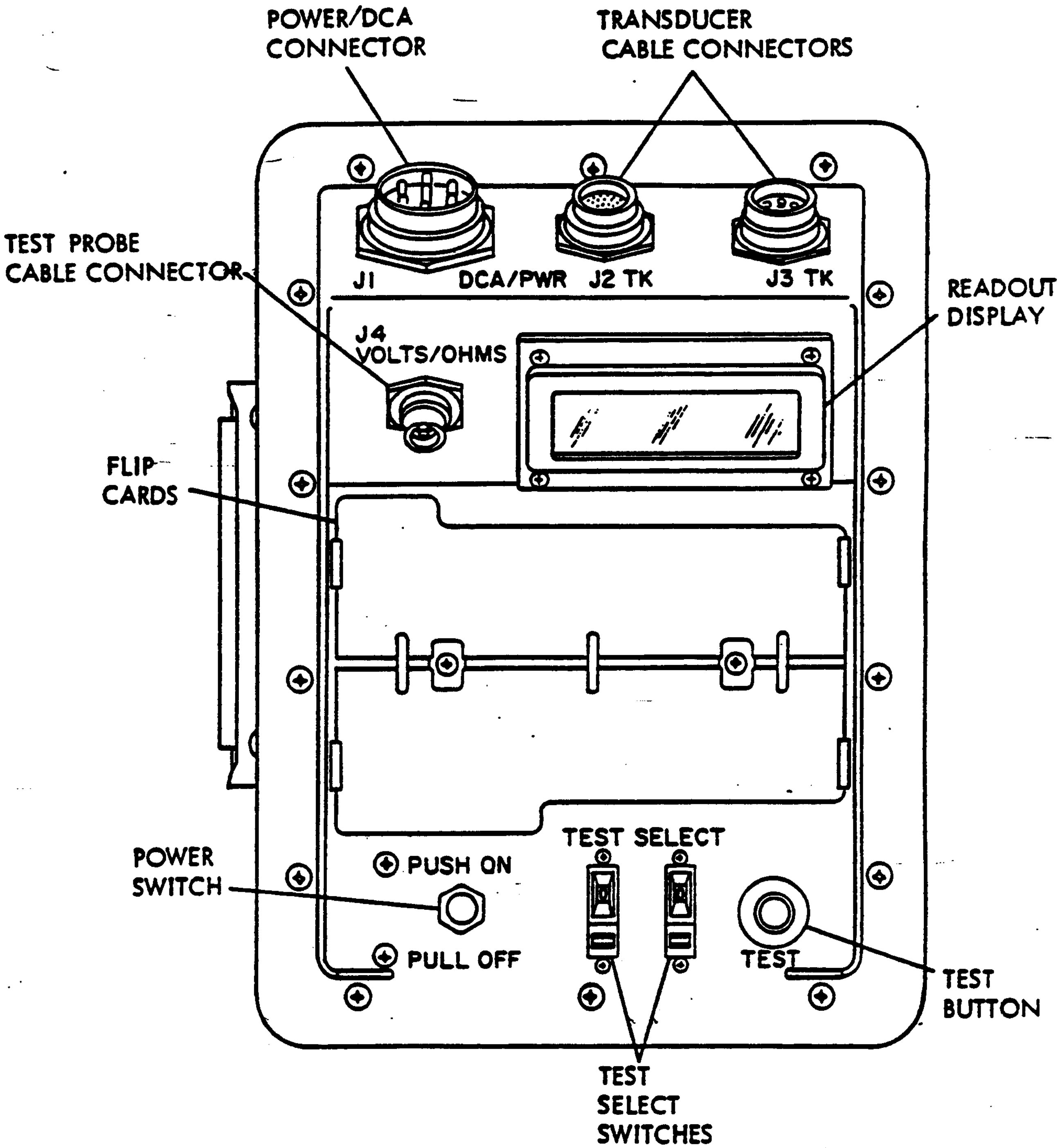

Figure 1-4. Vehicle Test Meter

operation mode, or incorrect vehicle operation. Confidence Test (Self-Test) messages indicate VTM performance and are also used at the DS level as an aid in repairing a faulty VTM. There are ten status messages, nineteen prompting messages, twenty-eight operator error messages, thirty-eight Confidence error codes and ten reprogramming error codes.

1.3 Generic DCA Concept

The diagnostic connector assembly (DCA) is mounted on the vehicle/equipment, and allows the VTM to make measurements on the engine and accessories. The wiring harness for this connector is attached to a number of electrical test points and transducers inside the vehicle/equipment. This allows the user to determine the condition of the vehicle/equipment without disassembling the equipment to gain access.

Vehicles/equipment are categorized into fourteen generic classes based on engine, fuel system, and the similarity of sensor complement. Each generic DCA is identified with a code resistor in the vehicle/equipment harness. The VTM reads the code resistor and provides the proper processing and conversion constants to the vehicle/equipment sensed signals. Further test control is provided by the DCA Indicator, also wired into the harness, and the Vehicle Identification Code (VID). The DCA Indicator identifies the transducer excitation source and speed sensor information. The VID is dialed into the VTM switches (2 digits) to identify stored vehicle/equipment dependent test constants which vary within a DCA class for Power Test, Compression Unbalance, and Starter Current First Peak Test. Application of the DCA classes is listed below. A more detailed description is found in Appendix A.

Generic DCA Type Numbers	Vehicle Class
1 - 4	Vehicles with medium sized diesel engines
5 - 9	Vehicles with large sized diesel engines
10	Spark ignition engines
11 - 13	Optional second DCAs
14	Reserved

1.4 User Instructions and Documentation

Direction and guidance for the use of STE/ICE-R are provided by the STE/ICE-R Operator's Manual, VTM flip cards and the Vehicle-20 Technical Manual. The primary guide for set orientation and operation is ~~the STE/ICE-R Operator's~~ Organizational Maintenance Manual.

The STE/ICE-R Operator's Manual is supplemented by a Vehicle Test Card for each vehicle. Each card includes a summary of tests, limits, vehicle specific information, entry codes, VTM operator and error messages, TK hook-up instruction, and test sequence required to evaluate vehicle serviceability. Figure 1-5 shows a Test Card structured for DCA testing of the LVTP-7A1 USMC Amphibious Assault Vehicle.

Once the mechanic becomes familiar with STE/ICE-R and the diagnostic logic process, he will be able to troubleshoot by using the flip cards on the VTM and the Vehicle Test Card for that vehicle.

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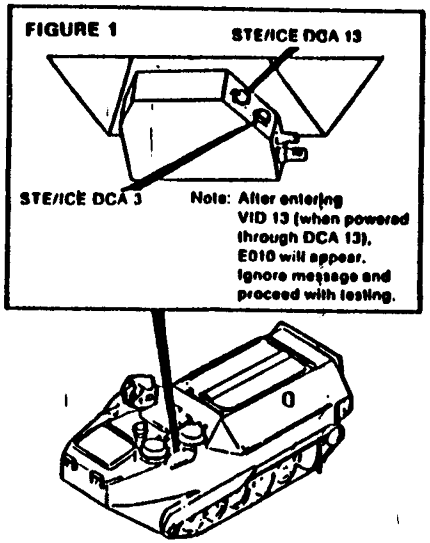
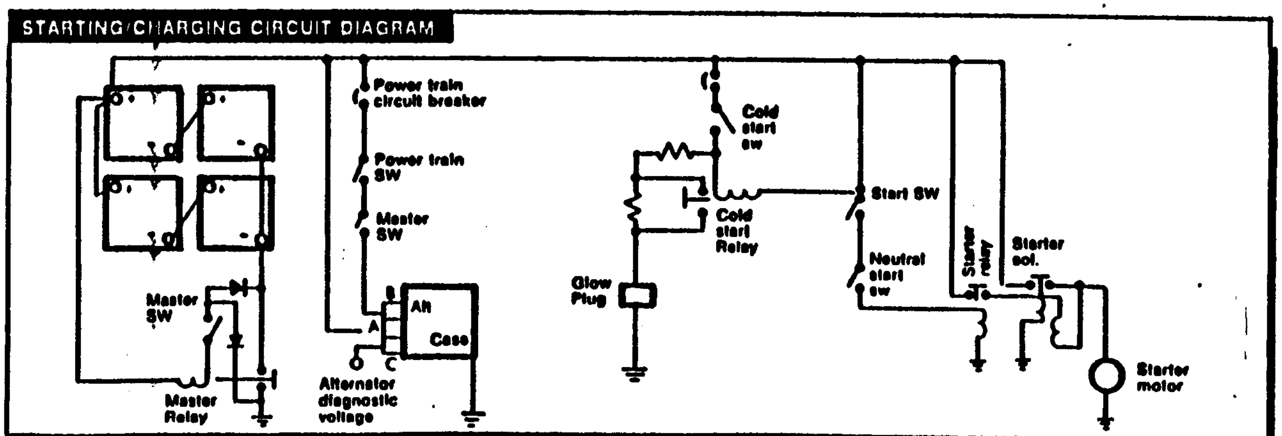
LVTP-7A1 VEHICLE TEST CARD - VID 13



MEASUREMENTS THROUGH DCA 13							
MEASUREMENT NAME	VTM TEST #	VTM OFFSET ⊿ LIMITS	OPERATING CONDITION	MIN	LIMITS NORM.	MAX	UNITS
Transmission Oil Pressure	39	±45	2000 RPM	175	180-200	—	PSI
Hydraulic System Pressure	40	±450	Idle*	240	—	400	PSI*
Fuel Filter ⊿P	42	±1.5	2800 RPM	—	—	4	PSI
Transmission Oil Filter ⊿P	44	±15	2800 RPM	—	—	**	PSI
Hydrostatic Steering Filter ⊿	38	±45	2800 RPM	—	—	75	PSI
Engine RPM	10	—	Idle	575	—	650	RPM
	10	—	High Idle	2950	—	3190	RPM
Power Tests (% Full Power) Compression	13	—	—	80	—	—	%
Unbalance	14	—	Warm Engine	—	—	10	%
Transmission Oil Temperature †	37	—	Normal Operation	140	170-235	305	°F

*While bilge pumps are on or while ramp is going up with engine speed at 1500-2800 RPM, pressure will be 1800-2100 PSI.
† After performing offset test, temperature is directly displayed.
**Limit not established.



Test limits given are advisory only and are not necessarily the same as vehicle TM's specifications. If test limits are different, use vehicle TM's specifications.

Figure 1-5. Sample Vehicle Test Card (Front)

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LVTP-7A1 VEHICLE TEST CARD — VID 13

PRE-TEST INSPECTION

1. Fan Belts
2. Oil Level
3. Coolant Level
4. Fuel Level
5. Batteries

POWERING UP VTM

1. Connect VTM to W1 cable. W1 cable attaches to vehicle DCA connecter (see Figure 1).
2. Enter VID into VTM using test 60.
3. Perform confidence test, test 66. (second entry 99)

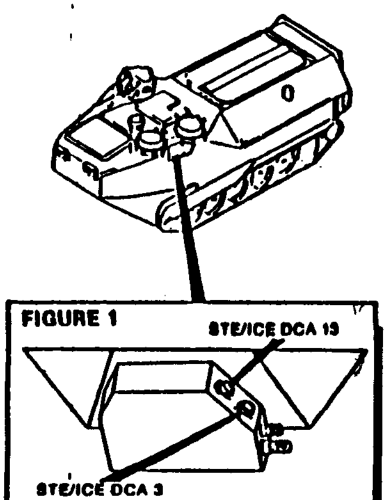

FIGURE 1

TABLE 1

RPM	FUEL RAIL PRESSURE LIMITS (PSI)
2650 - 2750	141 - 152
2550 - 2649	134 - 144
2450 - 2549	127 - 137

RPM AND FUEL RAIL PRESSURE MUST BE WITHIN LIMITS SHOWN.

MEASUREMENTS THROUGH DCA 3

MEASUREMENT NAME	VTM TEST #	VTM OFFSET LIMITS	OPERATING CONDITION	MIN	LIMITS NORM.	MAX	UNITS
Battery Voltage	67	—	Engine Off	22	—	—	Volts
Current First Peak	72	±225	Crank on Go**	800	—	1300	Amps
Engine Oil Pressure	35	±15	Warm Engine, Idle	10	—	—	PSI
Alternator Voltage	82	—	1000-1200 RMP Access. On	—	28	—	Volts
Engine Oil Temperature †	37	—	—	140	200-235	275	°F
Engine coolant Temp †	38	—	—	140	170-200	240	°F
Charging Voltage	67	—	1000-1200 RPM Access. On	—	25-29	30	Volts
Engine Oil Pressure	01, 35	—	Warm Engine, 2800 RPM	40	—	80	PSI
Engine Oil Filter ΔP	01, 36	±3.75	Warm Engine, 2400 RPM	—	—	24	PSI
Engine RPM	10	—	Governor	2950	—	3190	RPM
Air Cleaner Filter ΔP	01, 28	±9	2800 RPM	—	—	25	IN H_2O
Power Test % Full Power	13	—	—	80%	—	—	RPM
Engine RPM	10	—	Idle	625	650	625	RPM
Compression Unbalance	14	—	Warm Engine	—	—	—	%
Battery Resistance	73	± 225	Crank on Go**	—	25-29	13	Milliohms
Starter Circuit Resistance	74	± 225	Crank on Go**	—	3-22	25	Milliohms
Battery Resistance Change	75	± 225	Crank on Go**	—	—	25	Milliohms/Sec
Starter Positive Terminal Voltage	68	—	Cranking	17	—	—	Volts
Starter Negative Cable Drop	69	—	Cranking	—	—	1.2	Volts
Starter Solenoid Voltage	70	—	Cranking	18	—	—	Volts
Battery Current	80	—	Cranking**	35	—	550	Amps
Alternator Diagnostic Voltage	83	—	1000-1200 RPM, Access. On	—	Not Available	—	Volts
Alternator Negative Cable Drop	84	—	1000-1200 RPM	—	—	0.5	Volts
Fuel Rail Pressure and Speed	01,24	±35	4th Gear Stall Check*	—	See Table 1	—	PSI

*See vehicle technical manual for correct procedure for performing stall check.
† After performing offset test, temperature is directly displayed.
**If offset is performed for any one of the following tests, 72, 73, 74, 75, 80, then offset need not be repeated when doing any of the other tests.

Test limits given are advisory only and are not necessarily the same as vehicle TM's specifications. If test limits are different, use vehicle TM's specifications.

Figure 1-5. Sample Vehicle Test Card (Back) (Cont.)

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For new vehicles/equipment to be fielded with DCAs, tests and troubleshooting procedures using STE/ICE-R are to be incorporated into the vehicle/equipment manuals. The vehicle test card heretofore issued as a separate document will be included in the troubleshooting portion of the vehicle technical manual. Remember that the DCA tests can be supplemented with additional TK tests and procedures. The STE/ICE-R Operator's Manual and Vehicle Test Cards can serve as guides for the content and format of information to be presented in the Vehicle Technical Manual.

CHAPTER 2
VEHICLE TEST CONSIDERATIONS

The main goal of STE/ICE-R is to rapidly assess vehicle operational readiness and, if a problem exists, to quickly fault isolate to a replaceable item. Implementing a generic DCA on your vehicle/equipment will provide the parameters to satisfy the test requirements for the power plant and related accessories. If additional parameters or other vehicle/equipment system tests are desired they may be implemented with an optional second DCA, with the Transducer Kit mode of tests and/or by customizing the standard DCA. A study of the STE/ICE-R tests and Generic DCA parameter listings is useful in verifying that the proper DCA selection has been made.

2.1 Selection of DCA Class

DCA class selection for your vehicle is based on engine type, fuel system, sensor assignment, and VTM processing and scaling. Refer to the column labeled Engine Types in Appendix Table A-1 to find the DCA class that best describes your vehicle/equipment. Next refer to Table A-2 to determine similarity to the vehicles serviced by STE/ICE-R. Detailed on this table are the vehicles and engines assigned to the classes. These two tables should enable you to determine the primary DCA class for your vehicle/equipment type. Next, review the detailed Individual DCA Description for the selected class in Appendix A-3. The DCA description defines the basic test function, vehicle connection and required signal to be accessed by the diagnostic connector.

2.2 Vehicle Test Needs

A good starting point for allocation of STE/ICE-R tests to the Diagnostic Connector Assembly or to the TK mode of operation is Appendix C of this document which provides summary information on all tests useful in applying STE/ICE-R to your vehicle/equipment.

Table C-1 describes VTM Control, Confidence and Entry tests used in all modes of operation.

Table C-2 describes tests generally available to DCAs 1 through 10 and identifies the diagnostic connector pins used for each test.

The pin information is particularly useful in identifying which tests can be performed through the vehicle connections of your DCA. Note that tests in Table C-2 are not available to all DCAs and that pin allocations may vary by DCA. DCA applicability is shown in the right column. Note also that DCA 10 is for spark ignition engines only.

In most cases the tests available for each DCA class are adequate to meet the vehicle's organizational maintenance requirements. However, should you decide that the available tests do not adequately maintain and diagnose your vehicle/equipment, you can implement a second DCA connector, DCA classes 11 - 13 or you may wish to customize one of the standard DCAs to implement your test needs adequately. Table C-3 lists the additional voltage, temperature, and pressure tests available

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on DCAs 11 - 13. Examples of tests that could be implemented are transmission oil pressure or temperature, hydraulic system pressure, electrical test points, or exhaust temperatures. Be aware that some measurements are essential as vehicle/engine design parameters, but are not required for serviceability or diagnostic evaluation. Chapter 5 will give you the needed guidelines for the proper approach to customizing your DCA.

Specific information and examples of vehicle/equipment test points and connections are given in Appendix D. Together Appendices C and D provide a guide on where to make the vehicle/equipment connections. The tests in the Transducer Kit mode of operation are summarized in Table C-4. Extensive test capability paralleling the DCA mode is available with test probes and transducers that are temporarily connected to the vehicle. These tests can supplement the tests available at the DCA connector(s), particularly if the test points are readily accessible or if deeper diagnosis is required. Make note of which TK tests will be used on your vehicle/equipment and insure that the vehicle/equipment test point is readily accessible and compatible with STE/ICE-R.

2.3 Test Allocation Matrix

To organize and allocate tests to the primary DCA or optional second DCA, the structuring of a Test Matrix as illustrated in Table 2-1 is recommended. In the first column, list the tests that are necessary for maintaining and diagnosing your vehicle. Then for each test, determine if the primary DCA (the vehicle's own DCA class) accesses the parameter to perform this test. If this test is available, place a YES in the column; if it is not available, place a NO in the column and proceed to check if this test can be performed using the secondary DCA connector. Place a YES or NO in this column depending on the results of your investigation.

Table 2-1. Sample Test Allocation Matrix

Vehicle Parameter	Primary DCA DCA 3	Secondary DCA DCA 11-13
Alternator Output Voltage	Yes	
Alternator Field Voltage	Yes	
Air Cleaner Filter Delta P	Yes	
Battery Voltage	Yes	
Battery Resistance	Yes	
Battery Resistance Change	Yes	
Compression Unbalance	Yes	
Engine Oil Pressure	Yes	
Engine Oil Temperature	Yes	
Engine Oil Filter Delta P	Yes	
Engine Coolant Temperature	Yes	
Engine RPM	Yes	
Fuel Supply Pressure	Yes	
Fuel Filter Delta P	Yes	
Hydraulic System Pressure	No	Yes
Hydraulic Steering Filter Delta P	No	Yes
Power Test	Yes	
Starter Current First Peak	Yes	
Starter Circuit Resistance	Yes	

Table 2-1. Sample Test Allocation Matrix (Cont.)

Transmission Oil Pressure	No	Yes
Transmission Oil Temperature	No	Yes
Transmission Oil Filter	No	Yes
Turbocharger Outlet Pressure	Yes	
Ramp Lowering Solenoid	No	Yes
Ramp Hydraulic Motor	No	Yes

As a general test philosophy, DCA tests should diagnose and isolate faults to a depth that results in maintenance actions allowed at the organizational level of maintenance. STE/ICE-R test capabilities may permit organizational performance of maintenance actions formally relegated to DS.

2.4 Essential VTM Inputs

For proper operation of the VTM on a vehicle/equipment, the VTM must have provided to it the functions listed in Table 2-2. The connections for these functions permit measurement of engine power, compression unbalance, engine speed under all conditions, battery voltage, starter negative cable voltage drop and support a number of other tests.

Table 2-2. Essential VTM Functions

Function	Pins
VTM Power	E, F
Code Resistor	h, j
DCA Indicator	D, f, g
Engine Ground	M
Battery Voltage Sense	V, W
Engine Speed	
DCAs 1 - 9, 11 - 13	c, d
DCA 10	H, J (Shield K)
ALT/GEN Output Voltage	N, W
ALT/GEN Field Voltage	O, M
ALT/GEN Negative Cable Voltage Drop	W, P
Fuel Solenoid Voltage	R, M
Starter Voltage	T, W
Starter Current First Peak & Average	X, Y, V, W
Starter Circuit Resistance	X, Y, V, W
Battery Internal Resistance	X, Y, V, W
~~Battery Internal Resistance Change~~	~~X, Y, V, W~~
Fuel Supply Pressure	u, v
Fuel Filter Restriction (Delta P)	s, t

2.5 Essential Test Functions

For proper DCA implementation on a vehicle/equipment, the DCA connector must have provided to it, all of the functions shown on the skeletal schematic. Any deviation from this policy must be justified from a technological, logistic and economic standpoint, coordinated for concurrence with the TMDE/ATE Office and approved by the TACOM Commanding General (See Appendix E).

2.6 Test Point Accessibility for TK Tests

Primary factors leading to poor maintenance are the lack of test point access and difficulty of test. An awareness of available tests, test equipment, testing environment, and a conscious effort to design in accessible test points for both physical and electrical parameters is required. Minor provisions or modifications to your present vehicle design can provide a high life cycle cost return on a relatively small initial investment.

A method of test and accessibility must be considered for all functions omitted, or not available at, the installed DCA. The Test Allocation Matrix (Table 2-1) could serve as a check list to oversee this task.

Consider the following:

- Provide test plugs for pressure measurements; the two TK pressure transducers (-15 to 25 psi, 1000 psi) have 1/4 - 18 pipe threads. A separately available 10,000 psi transducer has a 37 degree flare fitting.

- Provide electrical test points.

- If the test point area is difficult to access, consider routing the parameter to a convenient area or test panel having pressure taps and electrical test terminals.

- Provide access to cables and wires for clamp-on Current Probe tests. This is particularly important if you choose not to install the current shunt in your DCA. Break out the individual wires to be tested from multi-wire cables and provide a sufficient length or loop to accept the probe and to minimize the flux field of the adjacent wires. Important areas of attention are battery, starter, and alternator/generator cables.

2.7 Test Limits and Vehicle Constants

STE/ICE-R performs both static and dynamic tests. The dynamic tests of concern are listed in Table 2-3. All other tests may be considered as static tests.

Table 2-3. STE/ICE-R Dynamic Tests

Test Number	Test Name
12, 13	Power Test
14	Compression Unbalance
72	Starter Current First Peak
73	Internal Battery Resistance
74	Starter Circuit Resistance
75	Battery Resistance Change

For the dynamic test, STE/ICE-R operates on both vehicle measurements at the DCA and VTM stored vehicle constants.

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For the static tests, test values and limits are typically the same as currently established by engine and vehicle manufacturers and noted in the vehicle TM's. Such values and limits should be reviewed with respect to the operating condition at which the test is to be performed, the test values that define normal operation or a failure, and the measurement accuracy of the STE/ICE-R tests.

The generation of vehicle constants and test limits is presently performed by the STE/ICE-R prime contractor and the vehicle manufacturer under the cognizance of TACOM. This capability will eventually be transferred to TACOM and separate guideline documents for the development of test limits and vehicle constants will be prepared.

2.8 Other STE/ICE-R Requirements

TMs: The vehicle manufacturer must incorporate STE/ICE-R tests into the vehicle technical manuals. Performance and troubleshooting procedures should make use of tests available in both DCA and TK modes of test. The manufacturer shall also generate the equivalent of a Vehicle Test Card for inclusion in the technical manual. The Vehicle Test Card provides a convenient and comprehensive summary of STE/ICE-R operation and test values applied to a specific vehicle.

Documentation: The vehicle manufacturer must develop DCA parts lists, schematics, wiring diagrams and harness drawings as required by the vehicle procurement contract.

DCA Harness Check Out: The vehicle manufacturer shall apply the appropriate test procedures to verify that the DCA harness is properly wired and free of errors that could damage the vehicle/equipment wiring and components, or the VTM. Recommendations for DCA harness checkout and fault isolation are presented in Chapter 7.

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CHAPTER 3
DCA COMPONENTS

3.1 DCA Standard Components

Standard components purchased to specifications and inspected in accordance with their associated Quality Assurance Requirements (QARs) will allow you to meet the functional performance and accuracy requirements of the STE/ICE-R system as spelled out in STE/ICE-R Specification MIL-T-62314A(AT). Table 3-1 lists the DCA standard components for which specification drawings have been developed.

Table 3-1. DCA Standard Components

Components	Specification Army Part Number
Pulse Tachometer, In-Line	12258931-1
Pulse Tachometer, Single-ended	12258931-2
Pressure Transducer (8 Ranges)	12258932
Temperature Sensor, Integral Bridge	12258933
Differential Pressure Switch - Multi-point	12258934
Differential Pressure Switch	12258938
Electrolyte Level Sensor	12258935
Shunt 1000 Amp/100 mV	12258937-1
Shunt 2000 Amp/100 mV	12258937-2
Connectors, Harness Transducer	
Contact, Stamped (Pin and Socket)	12258939
Insulator, Housing, Receptacle	12258940
Insulator, Housing, Plug	12259040
Connector, Receptacle 54 Pin	12258941
Cap, Dust	12258943

The diagnostic connector (12258941) must be used to interface with STE/ICE-R.

You are responsible for all quality assurance provisions associated with the purchase and application of the components. Quality Assurance Requirements (QARs) defining uniform inspection and test procedures exist for most of the sensors.

Experience to date has resulted in the establishment of suppliers for the DCA standard components. It is also anticipated that additions and revisions to the standard component listing and vendor sources are inevitable. Please contact your contracting officer for the revisions to the standard component listing and present sources of supply.

The standard DCA components are described in the paragraphs that follow.

3.2 Diesel Engine Speed Transducer

The standard DCA transducer for diesel engine speed* is a pulse tachometer which is simple in design and reliable. Similar devices are in production and in use on

*See Paragraph 4.14 for Spark Ignition Engine Speed Sensing

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commercial vehicles. In the DCA tachometer, a rotating disc magnet actuates a reed switch, generating two switch closures (pulses) per revolution of its own shaft. Figure 3-1 shows the output waveform of the tachometer.

The DCA tachometer is normally mounted at the tachometer takeoff on the engine. For these installations, one pulse per crankshaft revolution is desired. Since two pulses are generated per tachometer shaft revolution, the speed ratio of the takeoff shaft to the crankshaft determines whether a speed reducer is needed. On a four-stroke engine, the takeoff is usually driven by the camshaft which turns at half crankshaft revolution and a speed reducer is not required. Two-stroke engines require the 2:1 speed reducer before the tachometer since the camshaft turns at the same speed as the crankshaft. Some vehicle manufacturers install a 2:1 speed reducer between the tachometer takeoff and the tachometer cable to interface with the standard mechanical tachometer installed on the vehicle instrument panel. On such engines the DCA pulse tachometer should be installed after the speed reducer. If the buildup of components is excessive, a tee reducer having the 2:1 reduction can be substituted for the in-line speed reducer. For these applications the DCA indicator network shown in Figure 4-3(a) or 4-3(b) (see paragraph 4.5) directs the VTM to apply the speed conversion constant for one pulse per crankshaft revolution. The networks shown in Figure 4-3(c) or 4-3(b) are used with speed transducers that provide one pulse per two crankshaft revolutions. Such applications exists on a four-stroke engine using a magnetic pickup activated by a cam lobe on the camshaft.

Two configurations of the pulse tachometer are available: an in-line unit and a single ended unit. The in-line tachometer is inserted directly between the standard SAE tachometer drive on the engine and tachometer drive cable. This configuration retains the operation of the mechanical tachometer on the driver's instrument panel while providing the STE/ICE-R output. The single ended configuration is used when the mechanical cable drive is not required or when the tee reducer is used. Mount the pulse tachometer at the engine. Installation of the pulse tach at the end of a flexible drive cable is discouraged as cable torsion and whip may cause speed and related test results to be erratic.

3.3 Pressure Transducer

The standard DCA pressure transducer is of the diffused piezoresistive strain gage type and is widely used for automotive control and diagnostic functions. It is highly accurate and has a proven record of reliable performance in vehicle environments.

The strain gages that make up the sensor's bridge circuit are diffused directly into a silicon diaphragm using integrated circuit fabrication techniques. The diaphragms are relatively with high natural frequencies that can withstand the structural vibrations associated with diesel engines.

Eight pressure ranges are defined on the DCA Pressure Transducer Drawing 12258932. Typical applications are:

12258932-1	-15 psig	Manifold Vacuum, SI Engine
12258932-2	-5 psig	Air Cleaner Pressure Drop
12258932-3	10 psig	Fuel Supply Pressure - SI Engines Air Box Pressure - two stroke CI Engines

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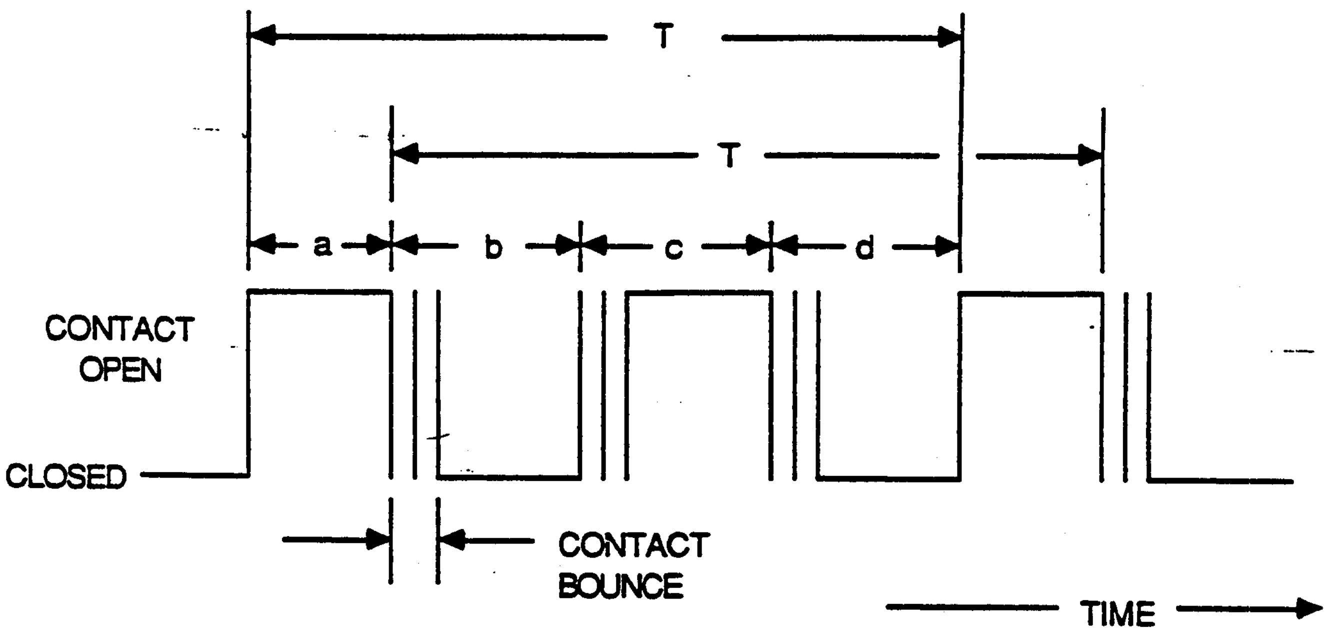

1.0 ROTATIONAL SPEED (RPM) = 60/T, WHERE "T" IS TIME IN SECONDS FOR ONE REVOLUTION OF TACHOMETER SHAFT.

2.0 TIME PERIOD "T" STARTS AT INITIAL CONTACT OPENING OR CLOSING OF ANY PULSE, PRIOR TO CONTACT BOUNCE.

3.0 MINIMUM DURATION OF EACH OF a, b, c, AND d SHALL BE 4.20 MILLISECONDS

4.0 DURATIONS OF a, b, c, AND d NEED NOT BE IDENTICAL.

Figure 3-1. Pulse Tachometer Output Waveform

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12258932-4	25 psig	Turbocharger and Airbox Pressures
12258932-5	30 psig	Fuel Supply Pressure
12258932-6	100 psis	Fuel Supply and Return Pressure
12258932-7	300 psis	Fuel Supply Pressure Transmission Oil Pressure
12258932-8	3000 psis	Hydraulic System Pressures

Caution: It may become necessary to install a pressure snubber or other pressure attenuation device between the transducer and the measured parameter due to transient pressure spikes. Pressure spikes are common in fuel injection and hydraulic system lines. The pressure spikes are reflected back to the transducer through the system line, sometimes at a pressure great enough to exceed the proof pressure of the transducer, thereby causing permanent damage. It is suggested that the pressure parameter being measured be thoroughly investigated to eliminate this potential problem.

The accuracy of pressure measurements are enhanced by two system techniques. One, the transducer output is ratiometeric; that is, the output varies as a function of both pressure and excitation voltage. The excitation voltage is measured in the VTM for each test, and a scale factor correction is applied for deviations from the ideal 12 volts. Two, when the transducer is powered from the VTM, the transducer and system zero offset error is stored during the calibration test and subtracted from subsequent measurements. The zero offset can be measured and stored whenever the sensed media pressure is reduced to 0 psi.

3.4 Temperature Transducer

The standard DCA temperature transducer is a resistive temperature device (RTD) with Wheatstone bridge completion at the sensor. This device exhibits good reliability and is compatible with the VTM differential measurement channels. Temperature detection depends upon the fact that for many materials (platinum, pure nickel, nickel-iron alloy) the resistance varies directly with temperature in a very reproducible way over a useful temperature range. The VTM interface requires that the DCA temperature transducer provide 0 - 100 mV output for a 0 - 300 F input. The temperature transducer output is ratiometric and scale factor corrections are made by the VTM for deviations in excitation voltage. Zero offset corrections for the transducer segment of the measurement chain are not practical since the measured temperatures, and therefore transducer output, will not go to zero when the engine is shut down. However, system accuracy is improved by eliminating the zero offset of the VTM. This is accomplished by installing a shorting switch in the output of the transducer to simulate a zero temperature as described in Paragraph 4.6.

3.5 Differential Pressure Switch

This unit consists of a spring loaded piston that moves as a result of the difference in fluid pressure on either side of the piston. The piston includes a magnetic element that opens a reed switch at a designated differential pressure set point. The Differential Pressure Switch measures clogging of fuel filters and provides a switch output to the VTM. It should be installed across the secondary fuel filter with the high or inlet port side tee'd to the filter inlet and low port tee'd to the filter outlet. The switch is a passive two wire device and does not

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have a polarity requirement. The set point of the DCA standard delta P switch, Part 12258938, is specified at 13.5 psid. Additional set points and dash numbers will be specified in the near future.

The magnetically actuated setpoint may be slightly affected if the unit is mounted directly on a large ferrous mass, such as the engine block. Mounting to a non-ferrous bracket, or spacing from the ferrous surface may be required. Refer to the drawing for mounting requirements.

3.6 Differential Pressure Switch, Multi-Point

This unit is similar in principle to the above differential pressure switch except three set points and corresponding output voltages are provided. In the Individual DCA Description, this device is applied to oil filters as a simple, reliable and low cost alternative to a "fully analog output" differential pressure transducer. The magnetic piston successively actuates three reed switches connected to a voltage divider network. With 12 volts (transducer excitation) applied to the network, a stepped voltage proportional to a differential pressure quartile of full scale range is outputted to the VTM.

As an example, the 25 psid unit with a 90 millivolt full scale output will produce the following values:

PSID RANGE	SET POINT 1 PSID	SET POINT 1 V OUT	SET POINT 2 PSID	SET POINT 2 V OUT	SET POINT 3 PSID	SET POINT 3 V OUT
0–25	6.25	22.5 mV	12.5	45mV	18.75	67.5mV

A Pressure drop less than 6.25 psid results in a zero output. When the pressure drop across the filter increases to 6.25 psid, set point 1 is tripped and the VTM senses 22.5 mV as one-quarter of the full scale output and will display 6.25 (psid). Set point 1 indicates that the pressure drop is at least one-quarter, but less than one-half of full scale.

The connector pin functions of this device must be observed. Refer to drawing 12258934 for mounting to a large ferrous surface.

3.7 Current Measurement Transducer

The standard DCA current measurement is a shunt. The shunt is an application of ohm's law; that is, the shunt is a calibrated resistance designed to produce an accurate voltage drop for a specified current range. The shunt should be located in the battery ground cable as illustrated in Figure D-1, Appendix D. Two shunt ranges are specified, 1000 and 2000 amperes. Each is configured for 100 millivolts full scale output. The ampere ratings define nominal values for identification purposes: not constant current application. The shunt physical sizing is based on values for starter peak current starter peak current, starter cranking current, charging current, and appropriate duty cycle for each. The VTM/shunt channel is capable of measuring a maximum first peak starter current of 1500 and 3000 amperes, respectively. Refer to drawing 12258937 for more details about the shunt's measurement capabilities.

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The shunt approach to current measurement is based on simplicity, ruggedness, reliability, long term stability and low cost.

3.8 Electrolyte Level Probe

Battery electrolyte level is sensed with a conductive probe installed at the battery cap/filler hole. The standard battery cap then screws into the electrolyte sensor to provide venting and submersion water proofing. A voltage is seen if the electrolyte level has not receded beyond the "add water" point. STE/ICE-R accepts a voltage reading of 3 - 20 volts on each electrolyte channel (pins Z, a, b) as a satisfactory electrolyte level. This means that the STE/ICE-R probe can be located in any but the two outermost cells (i.e., the cell nearest ground and the cell nearest the 24-volt terminal). If less than three probes are installed, the unused channels at the diagnostic connector must be connected to an active electrolyte channel. A 24K ohm resistor must be installed connecting each probe output to ground to prevent erosion of the submerged probe as described in Paragraph 4.7.

3.9 Diagnostic Connector

The diagnostic connector is a wall mounting receptacle with bayonet coupling and fifty-four AWG 16 rear release crimp female contacts. A resilient grommet and short end bell provide a rear seal against the insulation of the individual wires. Wire insulation diameters of 0.064 to 0.130 inch can be sealed. Also, use insert plugs in any unused contact locations to preserve the moisture seal and contact spacing. Provide a chained dust cap (12258943) for this connector.

3.10 Harness/Transducer Conncetors

The connectors required to mate with the DCA standard sensors are manufactured by ITT Cannon as the "Sure Seal Series" and were developed specifically for automotive applications. Each half consists of a single piece molded body. The receptacle half that mates with the transducers is specified on drawing 12258941. Male and female contacts are specified on drawing 12258939. Note that both male and female contacts are used in the multiple pin receptacles. Environmental sealing is maintained when wiring insulation of 0.100 to 0.147 inch diameter is used.

3.11 Qualifying New Sources

Purchasing of non-standard DCA transducers from new sources shall be done only to the Quality Assurance Requirement (QAR). The QAR requires that the new suppliers must submit and qualify pre-production samples and subsequently must perform quality conformance and periodic tests during production. Over and above the QAR, quality conformance examinations should be performed by the for new applications, the new QARs and specifications that must be written shall be done according to TACOM criteria (see Appendix E).

CHAPTER 4
DCA DESIGN DETAILS

This chapter presents design details relative to installation of the DCA. It addresses many of the questions and problems thus far posed by vehicle manufacturers in addition to providing guidelines for implementing the Diagnostic Connector Assembly and integrating it into the vehicle.

4.1 Overall Harness Layout

In general, the layout of the DCA harness divides into a vehicle chassis segment and an engine segment that normally requires passage through a compartment bulkhead. The chassis portion usually includes the diagnostic connector, battery connections, and other non-engine mounted test points. The engine segment should be connected separable from the remainder of the harness to permit rapid removal of the engine without having to disconnect transducers and electrical test points. The ideal location for the engine harness connector is at the engine compartment bulkhead (see Figure 4-1).

The harness must be routed to minimize damage from exposure to environmental elements, road debris and undercarriage abrasion on wheeled vehicles, excessively hot areas such as exhaust manifolds and areas subject to abuse. The DCA harness must be secured with adequate cable clamps and ties, particularly where the harness or cable weight and vibration could separate the friction mated transducer connectors. Intrinsic safety, particularly with respect to electrical test connections at potentially high current sources, must be considered.

4.2 DCA Connector Location

The diagnostic connector should be located in a relatively clean area protected from the weather, road splash, and accumulation of grease and grime. The preferred location is in the cab or vehicle enclosure near the driver's position. Mount the connector with its major key way upright at the 12 o'clock position. Provide adequate hand room to permit connection of cable W1. The VTM, connected to the diagnostic connector with cable W1, should be capable of being placed within the driver's view and reach. Cable W1 is eight feet long. This placement allows the operator to simultaneously operate the vehicle/equipment and the VTM. It also allows the operator to check parameters displayed on the vehicle/equipment instrument panel, which is especially useful when these parameters are not tested by the DCA. Install Dust Cap 12258943 to protect the connector when it is not in use.

4.3 No Sensor Measurement Channel Termination

As detailed in Chapter 2, all transducers and test point voltages in the Generic DCA Description may not be included in the DCA harness. For the omitted functions, an alternate "No Sensor" connection eliminates false or erratic VTM readings caused by the open circuits. Such readings may cause the mechanic to believe the vehicle or the STE/ICE-R is faulty and could lead to unnecessary fault isolation procedures. Pressure, temperature, and current sensors which ordinarily provide a differential output of +/-5 volts or less shall be replaced by a single resistor

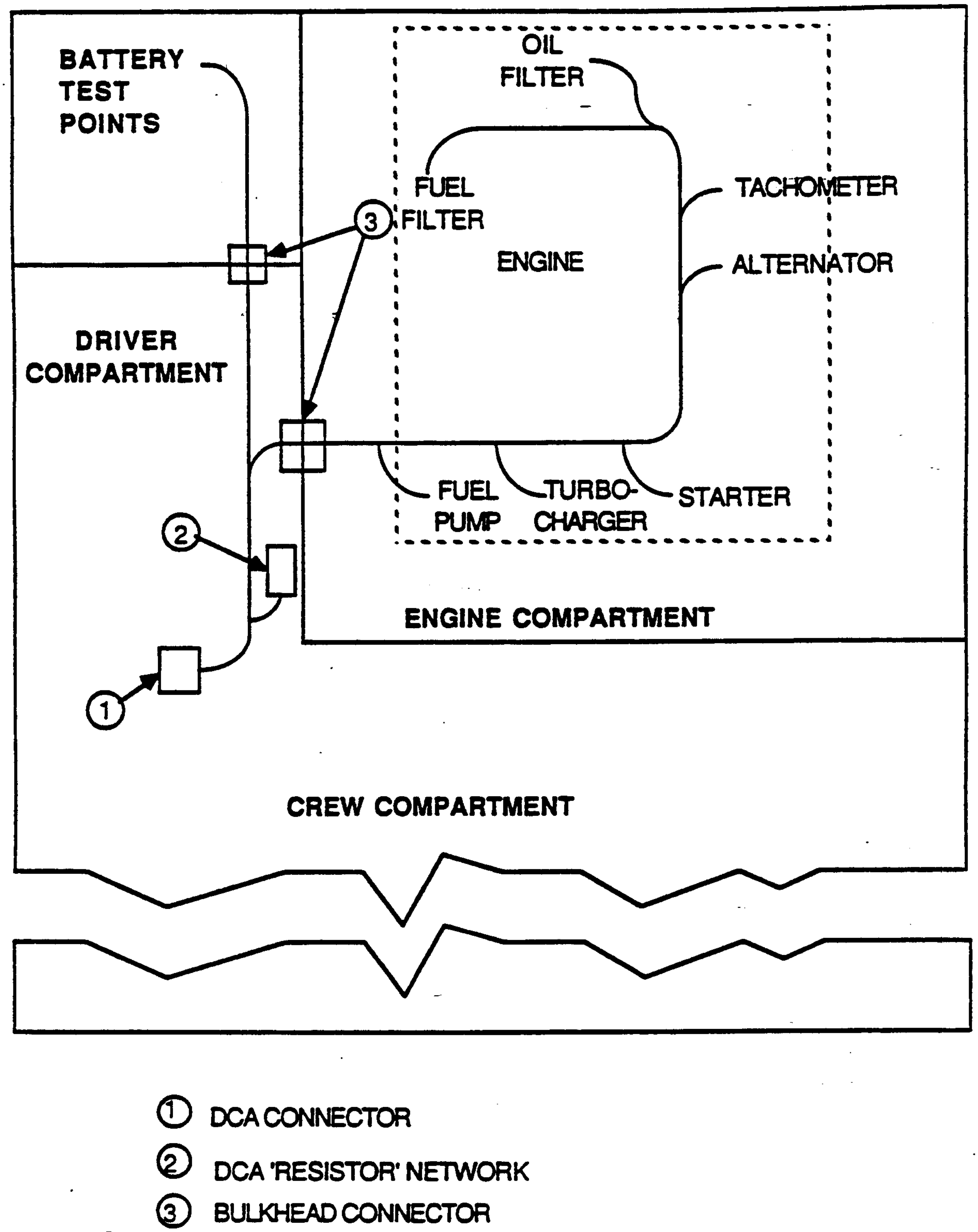

Figure 4-1. Sample DCA Harness Layout

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divider network as shown in Figure 4-2(A). All omitted transducer outputs may be connected to one divider network including those on a second DCA connector. The connection for omission of the fuel filter P function shall be as shown in Figure 4-2(B). For vehicle test points where a signal in the range of 0-32 volts would normally exist, and if all electrolyte sensors are omitted, a "No Sensor" networks should be installed as detailed in Paragraph 4.9.

4.4 Code Resistor

The vehicle code resistor is read by the VTM to select the conversion constants, gains, and filtering preassigned for each DCA class. The code resistor shall be of the RNR55/RNC55 type with a purchase tolerance of +/-0.5%. Values shall be in accordance with the individual DCA class description. The code resistor connects to pins h and j of the diagnostic connector and should be located on the resistor assembly discussed in Paragraph 4.9.

4.5 DCA Indicator

The DCA Indicator is required individually for each DCA installed in the vehicle. It provides vehicle information to the VTM in addition to that provided by the DCA code resistor. For diesel engines, the connection to pin "D" indicates whether vehicle mounted transducers (pressure, temperature, or oil filter P) are powered by the VTM or by the vehicle, and whether the pulse tachometer supplies one pulse per engine revolution, or one pulse per two revolutions. The appropriate resistor networks are shown in Figure 4-3. Resistors are the RNR55/RNC55 type with a purchase tolerance of +/-0.5%. For spark ignition engines, Figures 4-3(a) and 4-3(b) are used only to indicate how the DCA transducers are powered; pulse tachometer information is obviously not required since speed is derived from the points opening signal. The physical assembly and location of the networks are detailed in Paragraph 4.9.

4.6 Temperature Sensor Zero Offset Switch

A zero output from the temperature sensors must be simulated to eliminate the zero offset error in the VTM. Install a shorting switch across the DCA output wires for each temperature sensor. Locate the switch in an accessible place near the diagnostic connector and identify it. A typical connection scheme is shown in Figure 4-4.

4.7 Electrolyte Probe Trickle Current

It is necessary to maintain the probes at a negative potential to eliminate dissolution in the electrolyte. Install a 24K ohm load resistor between the DCA electrolyte wire (Z,a,b) and battery ground for each electrolyte probe. The current drain will be approximately 1 milliamp from each battery. See Appendix D Figure D-1A and D-1B for a connection illustration. The resistors may be grouped in one resistor assembly; see Paragraph 4.9.

4.8 Second DCA Connector Wiring Restrictions

When an optional second DCA (DCA 11, 12 or 13) is implemented on a vehicle, some functions cannot be shared with the primary DCA. The Code Resistor (Pins h, j), DCA Indicator (Pins D, f, g and associated resistors) and transducer excitation

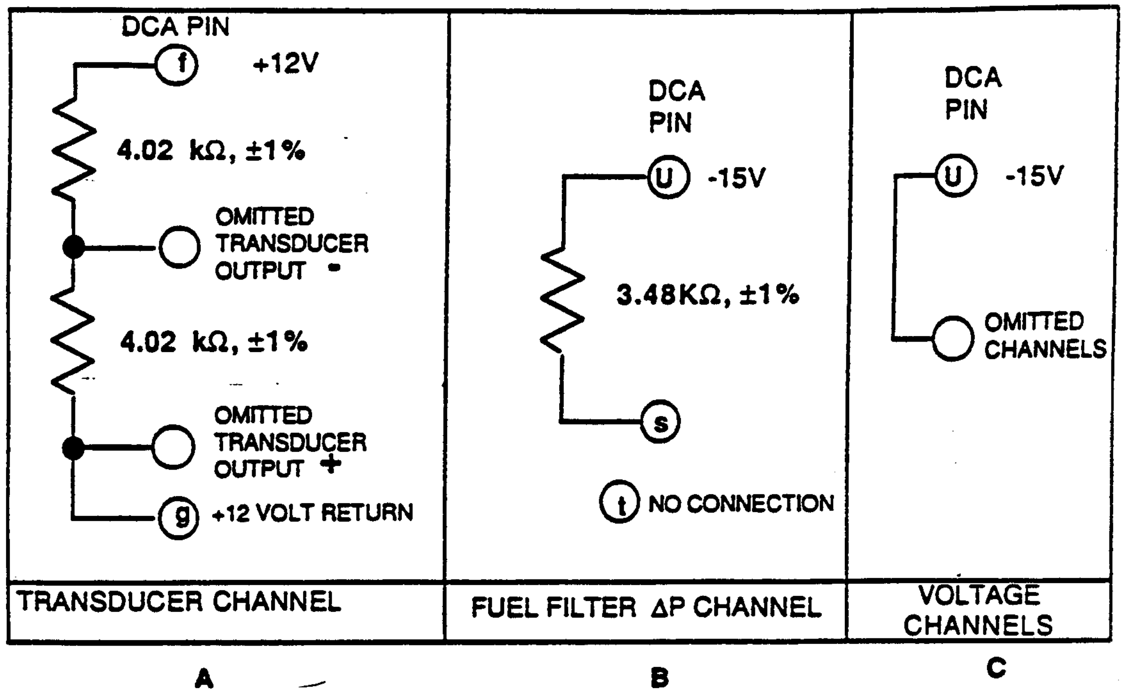

Figure 4-2. No Sensor Indicator Networks

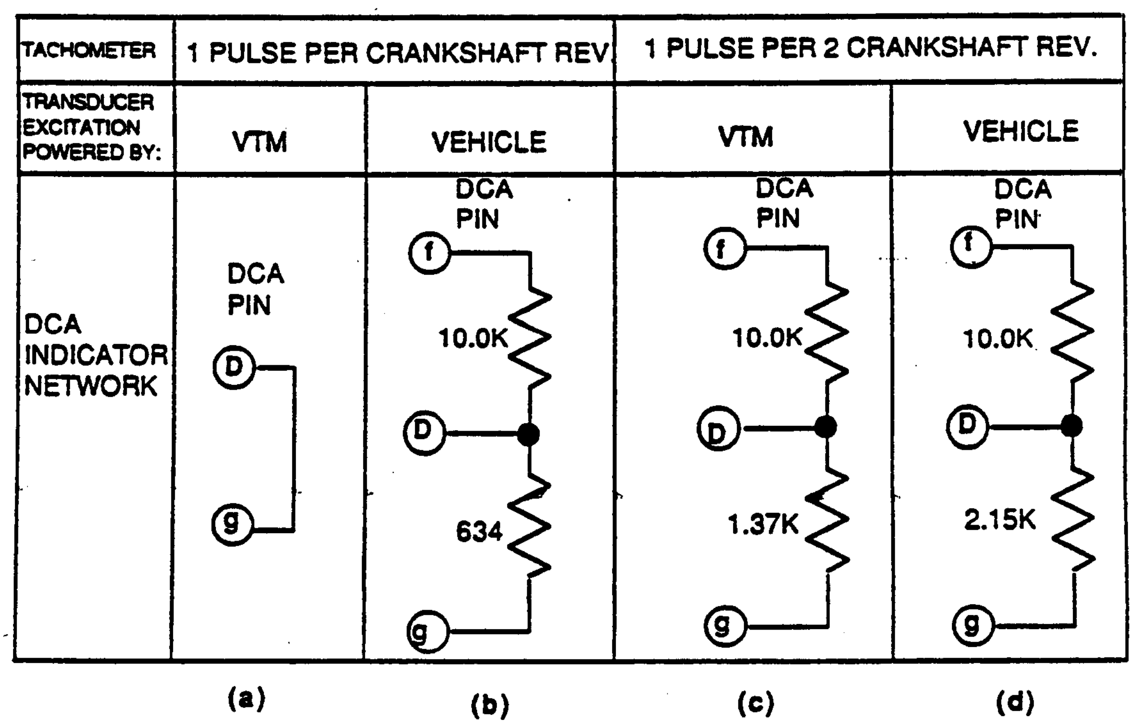

Figure 4-3. DCA Indicator Networks

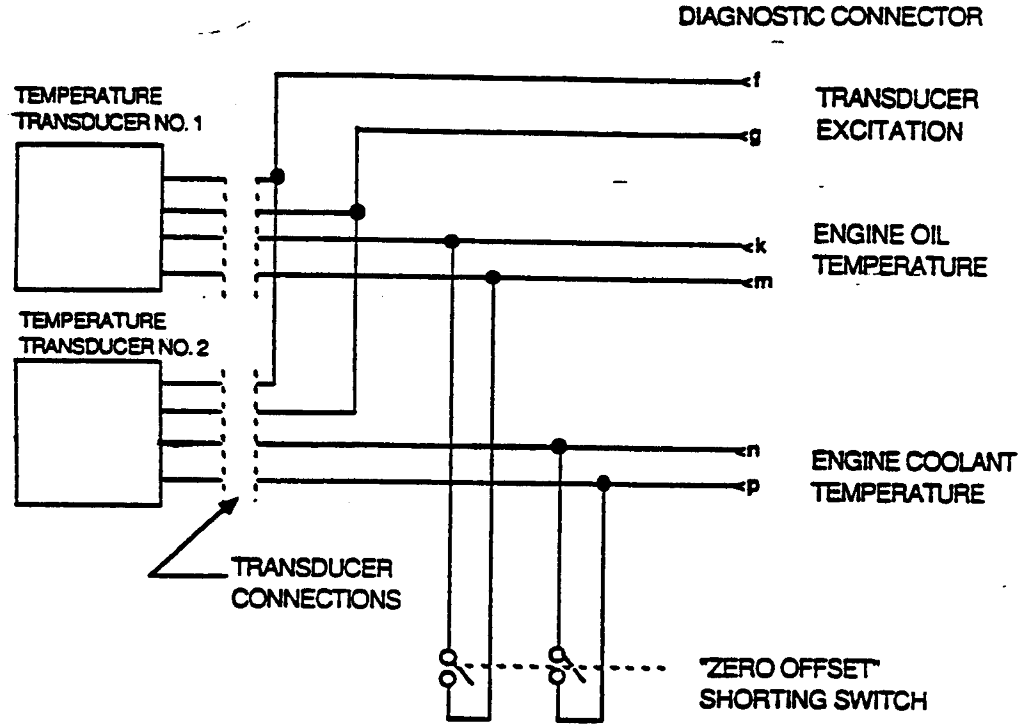

Figure 4-4. Temperature Sensor Shorting Switch

(Pins f, g) are required individually at both the optional DCA, and the primary connector. These functions cannot be shared between diagnostic connectors.

Other functions such as VTM Power, Engine Speed, Engine Ground, and Battery Voltage Sense may be shared and wired from the primary connector and need not be duplicated. Wiring may be simplified by jumpers across the diagnostic connectors or to a conveniently located terminal junction.

4.9 DCA Harness Resistor Assembly

Mount the DCA resistors and resistor networks on a separate component board (terminal or printed circuit) and mount the board in a well protected area or enclosure to provide protection from the environment. Insure access to the board for quick fault isolation when problems do occur. The board may be hard wired to the diagnostic harness. However, a separate module with connector disconnect(s) is recommended.

The "No Sensor Connection for the 32 Volt Channels" and "DCA Indication" are merely wire jumpers that can be made at the Diagnostic Connector. However, if many 32-volt connections are omitted on the vehicle, or if you anticipate electrical test point changes, it would be advisable to also locate these connections at the resistor board assembly.

A typical resistor assembly wiring schematic is shown in Figure 4-5. The schematic discloses the following characteristics of the DCA installation:

1. Tachometer output is 1 pulse per revolution of the engine crankshaft.
2. DCA transducers are excited (powered) from the VTM.
3. Fuel solenoid voltage connection is omitted.
4. Electrolyte trickle current resistors are installed in resistor assembly and connect to battery ground.
5. Coolant temperature and fuel return pressure transducers are omitted.
6. Code resistor, R1, identifies the DCA class.

4.10 Current Limiting Resistors

Current limiting resistors may be included in the wiring of all vehicles to prevent shorting of any of the high voltage lines (0 - 32 volts). Without these resistors damage may occur to the equipment in the event of an accidental short. They may be wired in-line or as actual resistors soldered between the connector and the wire. They may be installed as needed on pins M,N,O,P,R,S,T,V, and W. These resistors are not required for proper vehicle operation but are installed for vehicle/operator safety.

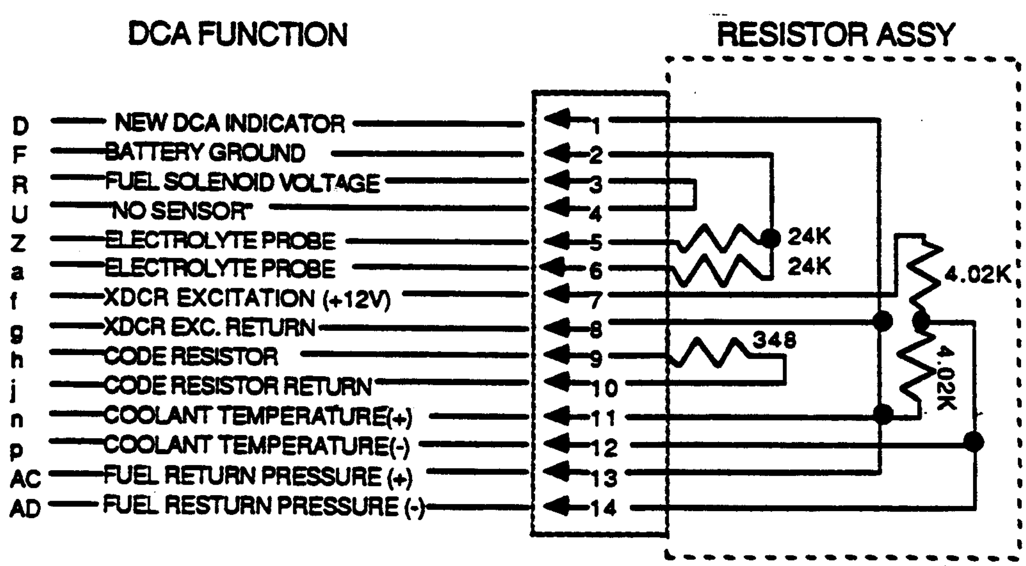

Figure 4-5. Resistor Assembly Schematic (Example)

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4.11 Vehicle Powered Transducers

In the design of a new vehicle, it may be possible to derive the required diagnostic signals from transducers or sending units installed for operational control or for the driver's instrument panel.

The signal output to the VTM of such sensors must meet the accuracy and electrical interface requirements of the STE/ICE-R system. Refer to the STE/ICE-R Specification, the Individual DCA Description and the specifications for the DCA Standard Components to extract the requirements for signal conditioning. Also refer to Table 4-1, which defines the general VTM input characteristics for the measurement channels.

If the transducers replacing the temperature, pressure, or oil filter P transducers are vehicle powered, be sure to use the proper DCA Indicator (Figure 9 (b) or 9 (d) to signal that condition to the VTM).

4.12 VTM General Input Characteristics

Table 4-1 summarizes the VTM input characteristics by DCA input pin numbers. Consult the STE/ICE-R contractor or TACOM AMSTA-RVD if you wish to implement tests having input signals that differ from those shown on the DCA description to determine compatibility with the assigned signal processing in the VTM.

4.13 Diesel Engine Cranking Tests

Several STE/ICE-R tests are performed under engine cranking conditions. These include Compression Unbalance, Starter Current First Peak, Battery Resistance Change, and other battery starter based tests. The engine must not start. Many diesel engine installations have a manually controlled fuel shutoff that will inhibit starting when the engine is cranked. If the fuel shutoff solenoid on your vehicle is automatically actuated through the engine electrical power switch, you must provide an alternate means to inhibit starting for performance of the cranking tests. An alternate method of inhibiting the engine would be to install a momentary switch next to the DCA connector, inside the vehicle drivers compartment, that would inhibit it from starting.

4.14 Spark Ignition Engine Speed Sensing

For SI engines, the speed signal is sensed from the coil primary voltage waveform. The signal can be obtained from either a standard breaker-point type or a solid state ~~saturated~~ transistor type ignition system. The vehicle electrical system may be 12 or 24 volts. Figure 4-6 depicts a typical primary voltage waveform that will interface with STE/ICE-R. Note that the saturation voltage cannot exceed one volt. DCA wiring connections are shown in Appendix D, Figure D-2.

During Compression Unbalance, the STE/ICE-R ignition interrupt feature disables the spark by limiting the collapse of the coil primary current. By limiting the change in the primary current when the points open or when the transistor turns off spark ignition is prevented while still providing a speed signal.

Table 4-1. General VTM Input Characteristics

DCA INPUT PIN NUMBERS	POLARITY	TYPE OF INPUT	MAXIMUM INPUT VOLTAGE	INPUT RESISTANCE	MAXIMUM INPUT BIAS CURRENT	COMMENTS
L N	+ +	Single-ended with respect to Battery Neg Terminal (W)	±35 Volts	35K Ohms	150 Nanoamps	1. AC, DC, or Frequency measured at these inputs. 2. Fullscale ranges: ±35, 3.5, 1.167 and 0.583 volts. 3. Bandwidths: 6,60,600, 6 kHz. 4. Assignments vary with specific DCA's
O R S T	+ + + +	Single-ended with respect to Engine Ground (M)				
V W	+ -	Differential				
Z a b	+ + +	Single-ended with respect to Engine Ground (M)				
k m n p u v w x y z AA AB AC AD X Y	+ - + - + - + - + - + - + - + -	Differential	±5v Differential ±5 at either input with respect to ground	5 meg ohms at either input or differential	1 microamp	1. AC, DC, or Frequency measured at these inputs. 2. Fullscale ranges: ±5, 0.5, 0.1667 and 0.0833 volts. 3. Bandwidths: 6,60,600, 6 kHz. 4. Assignments vary with specific DCA's
c d	+ RTN	Pulse Tach	±12 Volts	1.5K ohms pull-up resistor to +5 VDC		Max input frequency: 100Hz

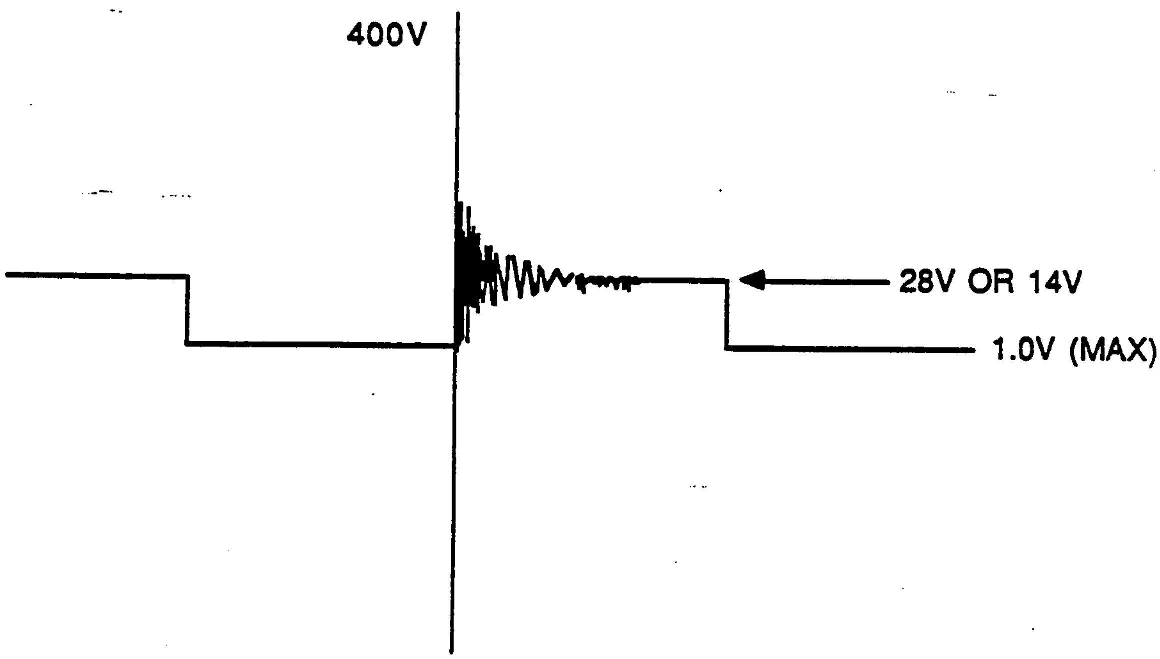


Figure 4-6. Primary Voltage Waveform

4.15 Magnetic Pickup Speed Sensor Circuits

For some installations, it may be convenient to use a magnetic pickup rather than the standard DCA Pulse Tachometer. The magnetic pickup may sense a cam lobe, gear teeth or other mechanical motion that correlates to diesel engine speed. The output must be conditioned (squared) to produce a waveform compatible with the tachometer signal requirements shown in Figure 3-1. Magnetic pickup applications generating multiple pulses per crankshaft revolution can be handled by adding a divide by N circuit, where N is the number of pulses generated by the magnetic pickup for each crankshaft revolution.

Figure 4-7 shows a sample circuit that detects the zero crossing of a magnetic sensor output and generates a square pulse for each crossing. This circuit may be applied to a magnetic pickup sensing the engine cam lobe. For a four-stroke engine, the camshaft rotates once for two rotations of the crankshaft. It follows that the circuit will output one square pulse for every two crankshaft rotations. Use the DCA Indicator networks of Figure 4-3(c) or 4-3(d) to identify the pulse-speed relationship to the VTM.

Apply the circuit in Figure 4-8 to process sensed inputs that are multiples of crankshaft speed, such as ring gear teeth. The output of the front end of the circuit, which is identical to the squaring circuit of Figure 4-7, is fed into a frequency divider. Set the binary word N7 N6 N5 N4 N3 N2 N1 N0 to the binary equivalent for N-1, where N is the number of sensed pulses (or teeth) relative to crankshaft revolutions. Use the DCA Indicator network shown in Figure 4-3(c) or 4-3(d) to identify the final pulse-speed relationship. The circuits of Figures 4-7 and 4-8 will accept up to 256 magnetic pickup pulses per revolution at crankshaft speeds up to 5000 RPM.

4.16 Differential Pressure Sensor Applications

Detection of filter clogging is measured in terms of differential pressure, i.e., pressure drop across the filter assembly. To conform to the generic DCA descriptions use the following sensors:

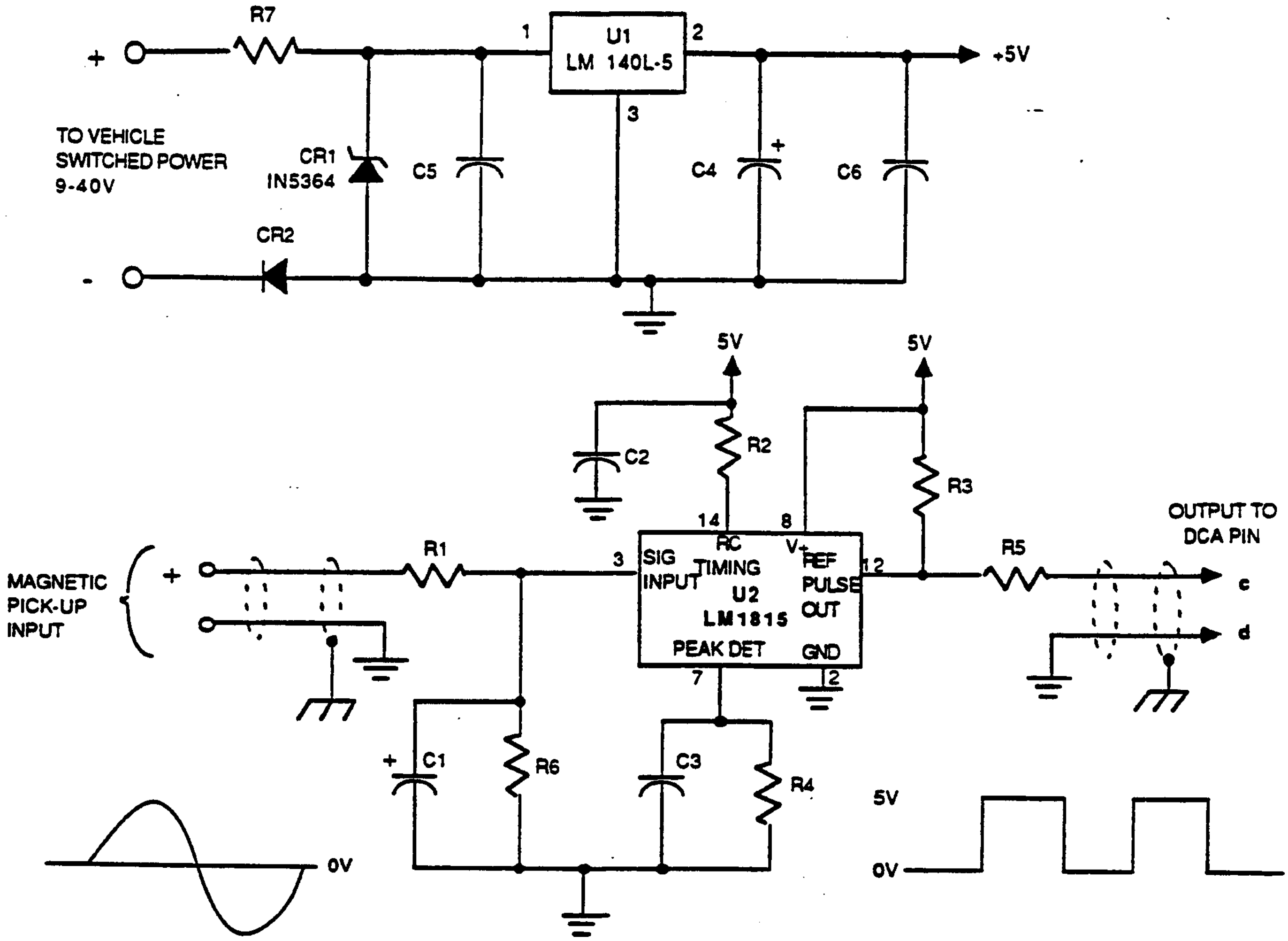
Fuel Filter: Differential Pressure Switch (12258938). This unit is a normally closed switch that opens at specified differential pressure.

Oil Filter: Differential Pressure Switch, Multi-point (12258934). This unit is powered from the VTM and provides three stepped output voltages relative to degree of clogging.

Air Cleaner: Pressure Transducer (12258932-2). This unit measures up to 5 psi vacuum referenced to ambient air pressure.

4.17 Pressure Transient Snubber

Be aware that transient pressure spikes commonly exist in fuel and hydraulic systems and can permanently damage the installed pressure transducers. Transients of 5 to 10 times normal pressures are typical. Also, backfiring in spark ignition engines creates high positive pressures in the intake manifold. Thoroughly investigate pressures that could exhibit transient pulses to determine the



1. SELECT C1 FOR MAX SIGNAL TO NOISE RATIO
2. R1 = (X-1) K OHMS; WHERE X = MAXIMUM PICKUP SIGNAL IN VOLTS. OMIT R1 IF MAXIMUM PICKUP SIGNAL IS LESS THAN 2 VOLTS.
3. WIRE FLOATING COIL MAGNETIC PICKUP USING SHIELDED TWISTED PAIR CABLE
4. 100mV MINIMUM REQUIRED AT U2 PIN 3
5. INSTRUMENTATION GROUND:
6. VEHICLE CHASSIS GROUND
7. CONNECT TO VEHCILE SWITCHED POWER: 9-40V

Figure 4-7. Magnetic Pickup Squaring Circuit

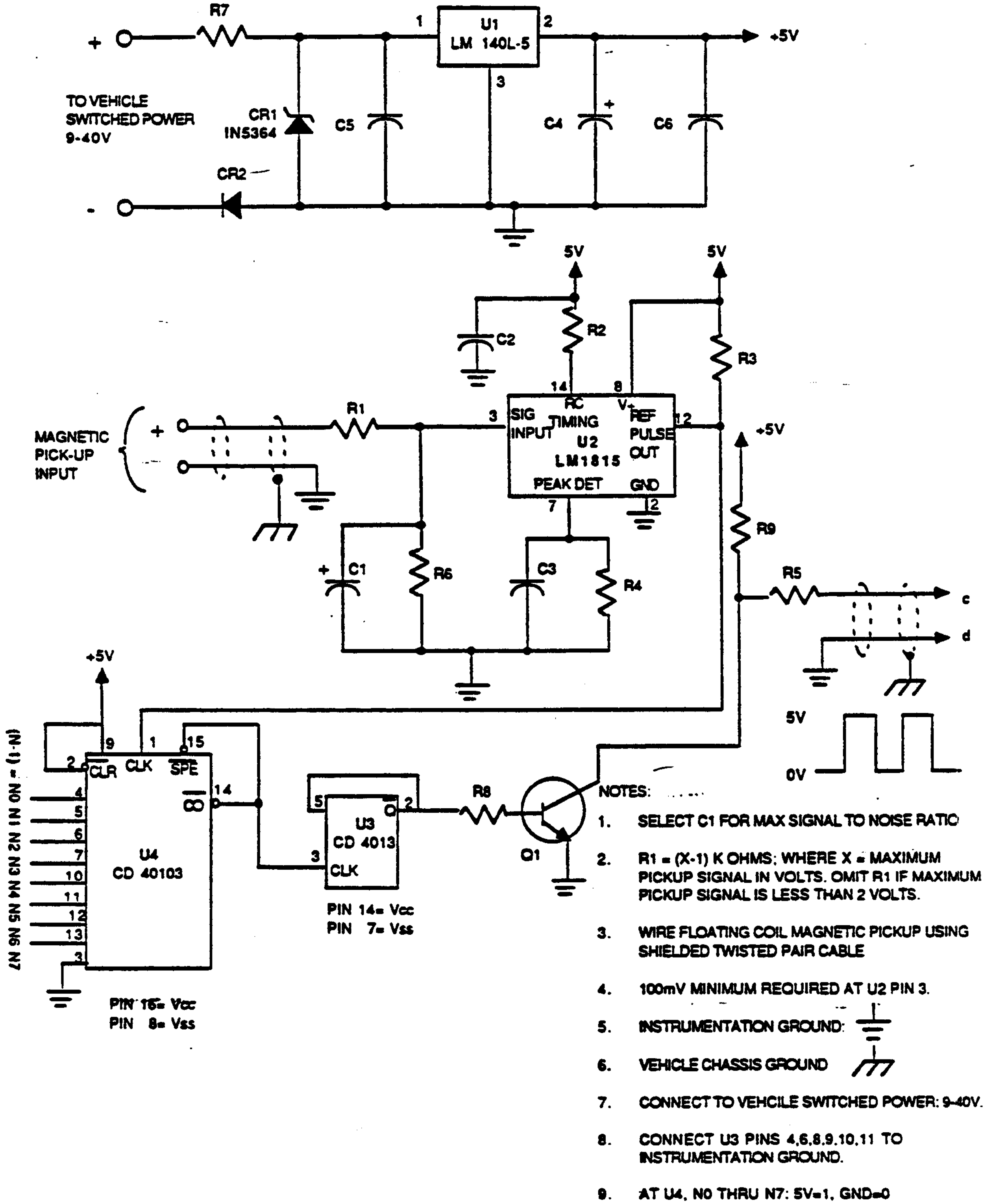


Figure 4-8. Frequency Divider

transient pressure content. Suppress the transients such that the maximum pressure applied to the transducer is less than the proof pressure. A snubber consisting of a sintered metal element can be used as a pressure transient suppressor. Its effectiveness relies on the:

- flow rate through the snubber element versus time duration of the pressure transient, and

- volume and compliance of the space between the snubber element and transducer diaphragm.

The sintered metal elements can be obtained in various sizes and porosity or as snubber fittings. An example is the TK snubber 12258881. However, other configurations of snubbers and methods of eliminating or suppressing excessive pressure transient spikes may be used.

CAUTION: Evaluate the location and buildup of components. Avoid extension of hardware susceptible to vibration failure or accidental damage.

4.18 Master Power Relay

The Master Power Relay is installed on your vehicle to enable the mechanic to disable all power to the vehicle accessories. There are two possible connections; either on the negative side or on the positive side of the vehicle batteries. The connections are shown in Appendix D, Figure D-1A and Figure D-1B.

4.19 Vehicle Connections

Specific information and typical examples of vehicle connections for the DCA connector pins are given in Appendix D.

4.20 User Selectable Function

Pin L of DCAs 1 through 4, 6 through 9 and 11 through 13 is reserved as an user selectable option. Tests 87, 98, and 99 will display the frequency, DC and AC voltages, respectively, present at pin L with respect to pin W. If this user selectable option is not used, pin L must be tied to pin U in the no-sensor configuration (see Section 4.3).

4.21 SAE J1708 Data Bus

Pins AE and AF of all 13 DCAs have been reserved for connections to the SAE (Society of Automobile Engineers) J1708 Vehicle Data Bus. Pin AE will be the positive connection and pin AF the negative. If your vehicle has no SAE J1708 Data Bus, leave pins AE and AF with no connection. For further information contact TACOM AMSTA-RVD.

4.22 Wire Considerations

The voltage and current requirements for the DCA wiring are relatively low. Vehicle steady state voltages are generally less than 30V and the VTM will draw 4.75 amps maximum. As a result, wire size selection is more a function of physical strength, particularly where individual or several wires are broken out of the main harness to transducers and vehicle electrical test points. Also, the use of ruggedized connectors to survive the vehicular environment forces selection of larger wire sizes than would otherwise be electrically adequate.

The following factors should be considered for wire selection:

- Diagnostic Connectors: Acceptable wire gage size for the crimp contacts (AWG 16-20) and insulation diameter to achieve moisture sealing in the rear grommet. Manufacturer recommends insulation diameter of 0.064 to 0.130 inch.

- Transducer Sure-Seal Connectors: acceptable wire gage size for the contacts (AWG 14-18) and insulation diameter to provide waterproof sealing in the elastomer body (0.100 to 0.147 inch). Use of insulation diameter less than addition of a sealing boot or a buildup of the wire insulation diameter where it enters the connector.

Overall wiring requirements, including harness, cable, connector, and termination identifications, must be in accordance with wiring requirements specified for the vehicle/equipment, which should include EMP, lightning and NBC washdown requirements.

4.23 Shielding Requirements

The requirement for shielding of low level transducer signals is defined as a function of transducer output and noise frequency. The maximum allowable peak-to-peak differential noise voltage over the applicable frequency range of DC to 1 megahertz is given by:

$$\text{Noise (p-p)} = \frac{10\,(\text{full scale output in mV})\,(\text{noise freq} + 10E{+}3\ \text{Hz})}{(\text{noise freq} + 10E{+}7\ \text{Hz})}$$

The noise voltage should be measured across the vehicle mounted DCA connector output pins for each transducer. Most noise problems can be minimized by applying normal suppression methods to the vehicle components, by physical separation of the diagnostic harness transducer wires from noise sources, and by routing the harness in physically protected areas of the vehicle.

If the noise level is still above the maximum allowable value, then shielding will be required to further suppress the noise signal. As a minimum, shielding is recommended for the pulse tachometer, VTM power leads (pins E and F) and the points signal.

Use twisted pair shielded cable and float the shield at the vehicle test point. Connect the other end of the shield to vehicle chassis ground near the diagnostic connector.

If shielding is required for the remaining transducers, it should be installed around the transducer wiring, terminating near the diagnostic connector as shown in Appendix D, Figure D-9. The shielding should be installed up to the transducer connector. Where the transducer wiring is bundled as it approaches the diagnostic connector, the wires may be grouped within one overall shield. The shield should be "grounded" only to a chassis ground on the vehicle at the diagnostic connector.

The shield should float at the transducer end of the harness and should be taped or insulated to eliminate multiple grounding points along the harness wiring.

CAUTION: SHIELDS SHALL NOT BE CONNECTED TO THE DCA CONNECTOR PINS.

4.24 Safety

This Design Guide is an advisory document. All designs and implementations of the Diagnostic Connector Assembly and its components must meet vehicle/equipment safety requirements.

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CHAPTER 5
GUIDELINES FOR CUSTOMIZING OF A STANDARD DCA

5.1 Customizing the Standard DCA

A standard DCA may be customized to better fit your test needs. The inputs listed in Table 2-2 are the inputs that the VTM needs, to run properly, and support a number of tests. They can not be eliminated, changed or substituted without written permission from the Commanding General.

The first step in customizing a DCA is to determine your DCA class. This is outlined in Chapters 1 and 2. After you have determined your DCA class, turn to Appendix A-3 and find your DCA class description and block schematic. These two sheets will provide a good starting point for customizing. Notice that all of the functions are shown on the schematic as being hooked up. In the schematic the pins are shown as being connected to rectangles. Rectangles only represent the vehicle components and transducers. The specific connection points are listed in the individual DCAs description. Also notice the DCA indicator network is wired for a tachometer output of one pulse per crankshaft revolution and the transducers powered by the VTM.

Next, determine which test points you wish to implement and if they are covered by your DCA. Eliminate test functions that do not pertain to your vehicle/equipment. By eliminating these "non-essential" test points you have opened up pins that can now be used for your individual test points. You may add any test point you deem needed as long as you keep the same transfer function and input limits for the described pins per the individual DCA description and the generic test descriptions (see Appendix B).

The final step is to implement the no-sensor configuration as shown on the bottom of your DCA block schematic and described in Section 4.3. Use the no-sensor configuration only for the DCA channels that have been omitted. If you use a transducer in your DCA, their is no need to use the no-sensor configuration for those pins.

Finally, if you plan to use non-standard transducers or components, be sure they are defined with specification equivalent to the DCA standard components. Write QARs (Appendix E) and impose pre-production qualification tests (to avoid future problems in the field).

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CHAPTER 6
DCA MAINTENANCE STRATEGY

6.1 Manufacturers Quality Assurance

Prudent quality assurance practices mandate both verification/test of transducers and harness assemblies prior to installation, and on-vehicle verification/test after installation. During the design stage of the DCA, test point location, harness location, and transducer type must be evaluated. Transducers and harness subassemblies must be bench tested before installation and finally, on vehicle checkout must be performed. On vehicle checkout may be performed with the same equipment specified for the field checkout. Automated testing is a viable alternative and should be evaluated on an individual basis if test times are a concern. If subassembly testing is performed prior to installation faults at final test should be limited to installation errors that can be easily checked.

Adherence to the following design practices will minimize failures that require troubleshooting both in the field and at the factory:

1. Do not apply the DCA merely as a specification requirement without evaluating the diagnostic utility and application to the specific vehicle. Locate transducers so as to derive true diagnostic utility and subject the DCA to TACOM review.

2. Evaluate transducer test point locations to minimize damage (e.g., away from high heat sources; pressure spikes on fuel and hydraulic lines).

3. Layout harnesses such that normal maintenance and power plant removal and replacement does not cause confusion in its reconnection or damage. All harnessing should be labeled and documented in the Vehicle's Technical Manual.

4. Specify only qualified DCA components (e.g., connectors; transducers) and vendors. Evaluate and Qualify all new vendors and products before use.

The factory personnel performing DCA testing, unlike those in the field, could reasonably expect to encounter multiple faults.

Proper pre-screening tests of the transducers and harnesses before final assembly will limit multiple faults. This leaves faulty installation in the vehicle of the various DCA components as the main problem area. Such errors as connectors inserted incorrectly, miswiring, and misplaced transducers can be easily checked and corrected. With a properly implemented design, the following factory tests are recommended for implementation.

1. Purchase transducers only to the Quality Assurance Requirement (QAR). Over and above the QAR, quality conformance examinations should be performed by the vehicle manufacturer.

2. Test the DCA harnesses prior to installation in the vehicle. (Automated cable tester (DITMCO or equivalent)).

3. Perform on vehicle DCA checkout as part of Government acceptance testing utilizing the existing DCA tester and a STE system/Factory Breakout Box test configuration. Automated testing with a hard output is a viable alternative, depending on DCA/vehicle electrical harnessing complexity, vehicle quantity, production rates and documentation needs. Cost would be a concern and should be considered.

Therefore, the following items are recommended for factory testing of the installed DCA:

Factory Breakout Box (Figure 6-1)
DCA Tester (Figure 6-2)
STE System
Documentation

The DCA Tester is an automated unit that checks specific DCA pins. It tests for over-voltage condition on the five volt channels, and voltages or grounds on shields and returns that should be isolated. The DCA tester checks only for wiring errors that may damage the STE/ICE-R VTM. No tests are performed for transducers integrity and, no tests are performed on the thirty-two volt channels.

The DCA Factory Breakout Box allows the user to the access and probe the various pins of the vehicles DCA safely. Access to the test lines are by banana jacks by which the STE/ICE-R VTM interfaces using the test probes. The J1 connector allows the user to utilize the existing W1 cable in the STE set for connecting to the vehicle DCA connector. The J2 connector ties the Factory Breakout Box with one of the TK connectors on the VTM utilizing one of the W4 cables. The "pig-tail" connector from the Factory Breakout-Box connects to J1 of the VTM. Terminals marked + and - are provided to bring the power to the VTM utilizing the W5 power cable.

The STE System includes three major items of equipment:

- Vehicle Test Meter (VTM).
- Transducer Kit (TK).
- Diagnostic Connector Assembly (DCA).

The VTM and TK comprise the STE/ICE-R set which is carried to the vehicle in a transit case. The VTM can be interfaced to the vehicle through the DCA or by use of the Transducer Kit.

The documentation should include vehicle harness drawings as well as vehicle specific test procedures in fault isolation.

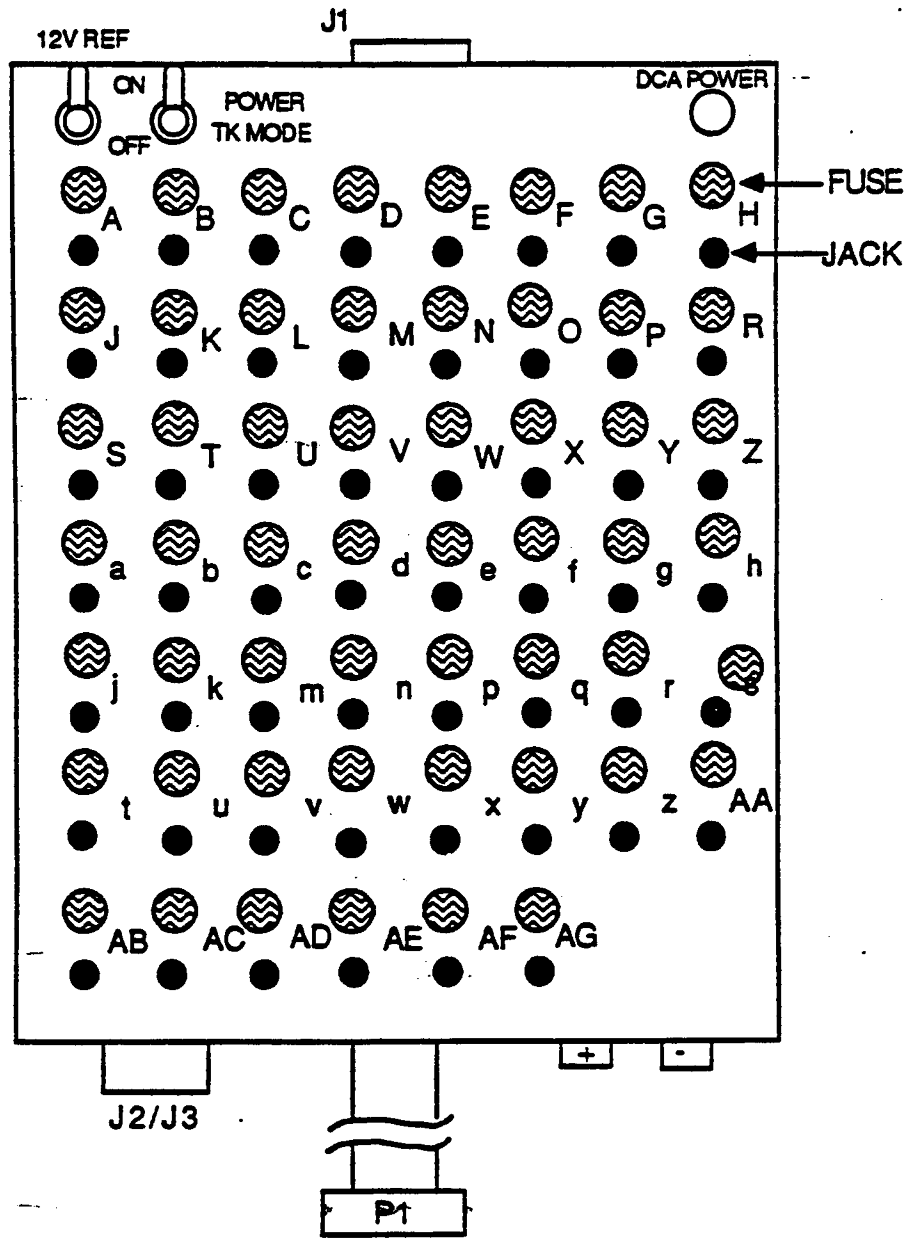

Figure 6-1. Factory Breakout Box

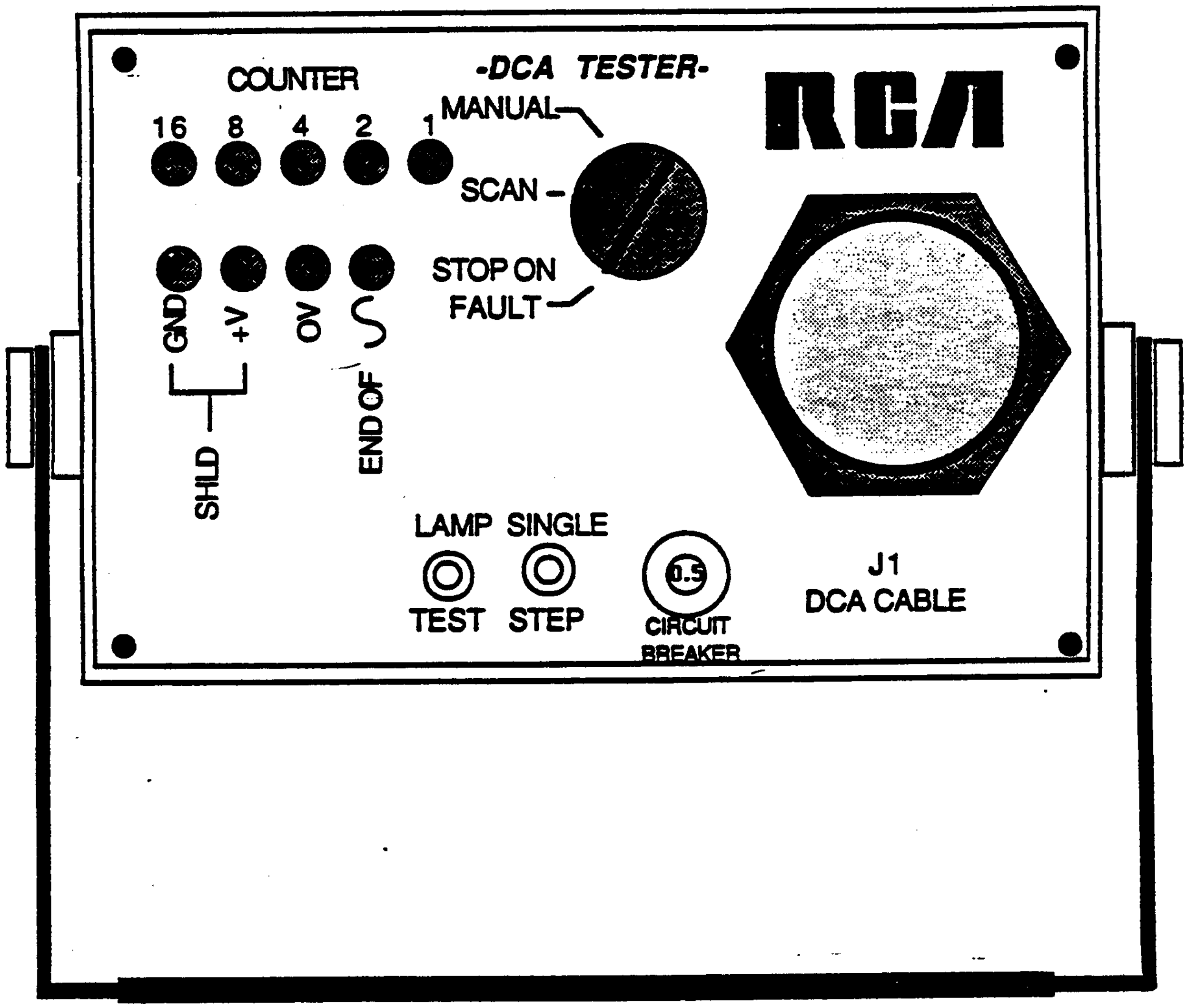

Figure 6-2. DCA Tester

6.2 Field Maintenance

Given that the design and factory tests are properly implemented, the mechanic in the field would be subjected to a low percentage of DCA failures. To check-out a vehicle's DCA in the field the following items are recommended:

Organizational Maintenance:

*Field Breakout Box
STE/ICE-R
Concise Documentation

Direct Support Maintenance:

DCA Tester
*Field Breakout Box
STE/ICE-R
Concise Documentation

The check-out procedure will be done as outlined in Chapter 7, DCA Harness Checkout and Fault Isolation.

*Special STE/ICE-R prime contractor test equipment.

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CHAPTER 7
DCA HARNESS CHECKOUT AND FAULT ISOLATION

7.1 Fault Isolation

Vehicle DCA harnesses must be tested prior to interfacing with a VTM to insure that wiring and connections are free of errors. After connecting the VTM to the vehicle/equipment DCA, a fault is indicated by a Confidence test error message or a .9.9.9.9 message appears while performing a STE/ICE-R Test. Error messages that appear can be caused by a faulty DCA or a faulty VTM. The fault isolation procedure is:

1. Disconnect the VTM from the DCA connector and test the vehicle/equipment pins(DCA connector), using the breakout box. Look for incorrect signal levels. See Table 4-1.

2. If the signal levels are correct, connect the VTM to the same diagnostic connector on a known good vehicle of the same type. Attempt the same test to see if the error message reappears.

3. If the error message reappears send the STE/ICE-R set to DS Maintenance for repairs.

4. If the error message does not reappear, proceed to test the DCA with the basic equipment for detecting and isolating faults in the harness, which are:

   Multimeter
   Field DCA Breakout Box (Figure 7-1)*
   DCA Tester (Figure 6-2)*

   *Special test equipment developed by STE/ICE-R prime contractor.

7.2 Troubleshooting a Broken DCA

There are three areas of concern when troubleshooting the DCA. They are:

1. To locate wiring errors that would damage the STE/ICE-R VTM when it is connected to the DCA.

2. To check the integrity of the transducers.

3. To test for opened or shorted wires in the harness from the DCA connector to the transducer.

The most economical way to obtain accuracy and a high level of confidence in the results of testing in troubleshooting a vehicle/equipment's DCA in a field environment is to use the STE/ICE-R VTM to perform all measurements and to supply power to the transducers that require it. Testing would be performed by utilizing the recommended Field Breakout Box to gain convenient access to the test points.

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